Electrical Engineering

September
1933

An Important Announcement

To improve and extend the publication service to each individual member of the American Institute of Electrical Engineers, to effect necessary economies by a rearrangement of procedure whereby present costly duplications can be eliminated, and to establish a flexible procedure more fully and more promptly responsive to the needs of the membership, a new policy, ratified by the A.I.E.E. board of directors August 8, 1933, henceforth will govern the Institute's technical publications. Briefly, the new program provides for a consolidation and unification of the Institute's technical periodical publications that will facilitate a more timely release of technical papers and the resultant technical discussion; that also will pave the way for a better balanced technical program and create an opportunity for a great improvement in the character and value of the technical sessions of conventions and District meetings. (Over)

Published Monthly by the
American Institute of Electrical Engineers

An Important Announcement of an Improved A. I. E. E. Publication Service

Continued from front cover—

Obviously, space forbids a full treatment of the subject here. The object of this preliminary announcement is to present concisely some of the salient features, which include:

1. The Monthly Publication. ELECTRICAL ENGINEERING will continue to be published monthly as the Institute's official technical organ and will become ***the*** primary publication by virtue of enlargement to include the full text of all recommended A.I.E.E. papers and the acceptable discussions thereon. This does not mean that any of the features that have proved so popular and that have helped to make ELECTRICAL ENGINEERING more useful to the membership since January 1, 1931, will be curtailed; quite the contrary, no effort will be spared to retain the standing of constructive leadership enjoyed by it and to keep it fully responsive to the evolving needs and desires of the membership. All special features that have proved to be of wide general interest will be retained in the present quota; some routine departmental material that has proved to be of but little value and only limited interest will be either omitted or reduced to a conciseness commensurate with its usefulness. Thus, every member of the Institute will receive month-by-month in a timely fashion, and in addition to the present "general interest" features, ***all*** the Institute's technical material. This is a further step in the development of an adequate publication program undertaken seriously by the publication committee in 1929 and continuously under consideration since that time.

2. The Transactions. In effect, the entire material now embraced annually by the quarterly volumes of the A.I.E.E. Transactions will be distributed month-by-month to the entire membership through the columns of the monthly publication. This will obviate the necessity for continuing the present unsatisfactory system through which part of the material appears in the monthly, part in the Transactions, and part in duplicate in both; also it will eliminate other inequitable and unsatisfactory conditions. Therefore, as now issued quarterly, the Transactions will be discontinued upon completion of the 1933 annual volume, and those who have felt the necessity of subscribing to the Transactions in order to receive all the technical material no longer will need to do so. For those who for any reason will wish to continue the collection of a library of bound volumes of A.I.E.E. technical material, an annual cloth bound volume will be issued at the close of each year embracing the contents of the 12 issues of the monthly for that year. Because this annual volume will be a duplicate publication and will be desired by only a minority of the membership, a nominal subscription price sufficient to cover the costs will be charged, probably about $4 (to members), the same as the present annual member's subscription price for the cloth bound Transactions.

3. Technical Papers and Discussions. Recognizing the fact that the prime object of the Institute is service to, and the edification of, its membership as a whole, the unified publication plan will bring current technical and other suitable material to each individual member in a far more timely fashion than previously has been possible. It is contemplated that technical manuscripts, to a large degree if not entirely, will be released for publication in ELECTRICAL ENGINEERING immediately upon the logical completion and technical review of the manuscript, instead of having the release of contemporary manuscripts rigidly and artificially geared to some advance convention or District meeting date. Discussion likewise will be expedited and, it is hoped, greatly improved in quality. Written discussion on technical papers will be in order, and acceptable for consideration for possible publication, subsequent to the publication of a paper. It is contemplated that at least the bulk of the important discussion on any given paper will be completed and published in the monthly perhaps within 90 days following the date of original publication of the paper itself. These and other opportunities for improvement of the Institute's technical program made available through the unified publication plan should in a large measure relieve the congestion that has damaged many a convention and District meeting technical session, and pave the way for those sessions to become again the constructive open forums for group discussion that they originally were planned to be.

4. Pamphlet Papers. Whereas under the unified publication program all A.I.E.E. technical material will reach the entire membership through the monthly issues of ELECTRICAL ENGINEERING, the production and free distribution of separate pamphlet copies of technical papers will be discontinued. To the extent that a demand for them may develop, either singly or in quantity, ***reprints*** of technical papers may be made available for sale at a very nominal price.

These points represent only the high lights of a plan that has evolved slowly through long study. The plan was reported to, and discussed at length by, the annual conference of officers, delegates, and members held in connection with the 1933 Chicago convention. That conference endorsed the plan and recommended it to the board of directors which ratified the plan at its meeting in New York August 8, 1933, thereby placing it in effect. In placing the plan in operation there must be, of course, a transition period during which a smooth change from the present to the new publication program can be accomplished simply and most economically and with the full protection and coördination of the various Institute activities involved. In general, however, it is contemplated that the program will be in full operation by the close of the current year.

During the next few months of transition, the important details of the unified publication plan will be presented and enlarged upon in the several issues of ELECTRICAL ENGINEERING. These monthly dissertations will endeavor to explain the most important details more fully, and to answer all important questions brought to the attention of the publication committee in the meantime. In connection with suggestions and queries that this preliminary announcement may inspire, it is suggested that members of each Section discuss the matter with the Section delegate who was in attendance at Chicago, thus obviating a mass of individual correspondence and correspondingly relieving the burden on the publication committee. In no way, however, is this suggestion to be taken as militating against individuals who cannot conveniently collaborate with Section groups. As indicated, these communications will guide subsequent explanatory published statements of the committee, and it is hoped that individual responses will be asked for only when necessitated by some special condition. To expedite the handling thereof, it is suggested that all general inquiries be directed to the secretary, A.I.E.E. publication committee, 33 West 39th Street, New York, N. Y.

Publication Committee

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th St., New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 52
No. 9

The JOURNAL of the A.I.E.E. for September 1933

PUBLICATION OFFICE, 20th and Northampton Streets, Easton, Pa.

EDITORIAL AND ADVERTISING OFFICES, 33 West 39th Street, New York, N. Y.

ENTERED as second class matter at the Post Office, Easton, Pa., April 20, 1932, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain, and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

STATEMENTS and opinions given in articles appearing in "Electrical Engineering" are the expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on all controversial matters.

ELECTRICAL ENGINEERING is indexed in Industrial Arts Index and Engineering Index.

Printed in the United States of America. Number of copies this issue—

16,000

This Month—

—Turn to Next Page

OPERATION of oil well drilling equipment is improved by the application of variable voltage d-c electric drives. A method of comparing various arrangements of equipment has been developed. *p. 617–21*

AUTOMATIC CONTROL of the concentration of solutions used in some industrial processes is a job recently assigned to that versatile device, the photoelectric tube. *p. 601–04*

FREQUENCY RANGE of the string type oscillograph has been extended to more than 10,000 cycles by the use of an electrical network to equalize the natural characteristics of the string. *p. 623–5*

FROM the results of a study of the magnetic properties of silicon sheet steel when symmetrically and non-symmetrically magnetized, an equation has been derived to express the relation between hysteresis loss and pulsating induction; this equation should be useful in designing apparatus for circuits in which alternating and direct currents are superposed. *p. 625–30*

PIN TYPE porcelain insulators that are claimed to be free from radio interference at their rated operating voltages have been developed by the principal insulator manufacturers during the past 2 or 3 years. Comparative tests on "interference proof" insulators of different designs reveal their relative merits. *p. 608–13*

A SELF-EXCITING commutator type generator has been developed for supplying electric power at low frequencies (a few cycles per second). Both the voltage and frequency of the output can be controlled easily so as to serve the many needs known and anticipated for energy in this form; furthermore, such a machine can be built at moderate cost. *p. 631–6*

TO DETERMINE the skin effect at commercial frequencies in solid non-magnetic rectangular conductors, an investigation has been conducted using high frequencies and conductor specimens of relatively small cross sections. From the basic data obtained, curves for any frequency can be calculated. The results are particularly useful in the design of buses for isolated-phase layouts. *p. 636–9*

OFFICERS AND COMMITTEES elected and appointed to serve the Institute for the ensuing year are listed in this issue. *p. 658–61*

MEMBERS of the A.I.E.E. and readers of ELECTRICAL ENGINEERING continue to express their varied opinions on topics of interest in "Letters to the Editor." *p. 646–9*

ENGINEERING SOCIETIES LIBRARY is said to be one of the most important coöperative activities of the 4 national societies of civil, mining, mechanical, and electrical engineers. *p. 649*

ENGINEERING SCHOOLS and their methods of instruction are believed to be due for a rather thoroughgoing reform as a result of the effects of the present changing economic and social order. *p. 604–05*

DIRECT observation of the electric and magnetic fields of the sun and planets obviously is impossible, but an analysis of observable phenomena reveals some information regarding the nature of those fields. *p. 621–3*

SPEED CONTROL for high voltage single phase electric locomotives is greatly simplified in a recently developed system wherein the entire heavy and bulky low voltage switch gear is replaced by a simple high voltage tap changer. A greatly improved acceleration is claimed for this system. *p. 613–16*

A NEW method of initiating the electric arc, an essential element in many types of engineering apparatus, has been developed. The method is claimed to have unusual features, and, when applied to gas filled electronic valves, is said to eliminate many of the problems associated with the use of control grids. *p. 605–08*

DISCUSSIONS of technical papers presented at the 1933 A.I.E.E. summer convention, some of which were summarized in the August issue of ELECTRICAL ENGINEERING, are continued in this issue. Subjects covered are: communication, power generation, electrophysics and related subjects, electrical machinery, and electric welding. *p. 643–6*

The Engineer and the New Deal

Signs seem unmistakably to indicate that the present upheaval in the social, political, and economic life of the United States will be as far-reaching as those following the Revolution and the Civil War. The place that the engineer will be able to claim in this changing society will depend upon his ability to change with it, to bring new scientific resources to bear, and to broaden the area in which he applies his characteristic procedures.

By
WILLIAM E. WICKENDEN
MEMBER A.I.E.E.

President, Case School of Applied Science, Cleveland, Ohio

THOMAS JEFFERSON is said to have remarked that every country needs a revolution about once in 20 years. Most of them need be only violent enough to bring into authority new ideas, new sets of values, and especially new leaders. The periodicity of major epochs in American history appears to be about 4 times as long as the interval Jefferson suggested. To establish the colonial system, to raise it to a state of self-sufficiency, to complete the expansion of the national domain while bringing 2 warring social systems to their final issue, and to create an industrial order of society have covered periods of about 80 years each. There are signs that we again have reached such a turning point. The last 2 of these epochs have been highly significant for the technical professions, and if a new deal is impending the engineer is likely to be profoundly concerned.

Opportunity began to beckon to engineers in America with the beginning of an independent and unified national life. The desire to make secure the national defense by military works, to bind the states together by improved communications, to increase the economic self-sufficiency by developing industries, to open access to the great West and bind it firmly to the nation, and to provide suitable public works for the newly developing cities literally called the profession into being.

With the warfare of social systems brought to a ruthless end in 1865, the country settled into the long and deep depression of the '70's, to emerge a wholly altered nation. One has only to call the roll of the dominant names of the half century leading up to 1870—Webster, Clay, Calhoun, Douglas, Lincoln, Davis, Grant, and Lee—and contrast it with the leaders of the following 50 years—Rockefeller, Carnegie, Edison, Bell, McCormick, Westinghouse, the Vanderbilts, the Goulds, and James J. Hill—to sense the significance of the change.

America had passed from a period of geographical and political pioneering into a period of technological and industrial pioneering. Before, one who sought to grow rich and powerful required land; thereafter, he amassed capital and exploited labor, inventions, or mineral resources. Business passed from the age of individual enterprise into the age of the corporation and the trust. Isolated railway lines were welded into transportation systems. Cities grew rapidly and the rural ideas which an earlier America had written into its Constitution began to yield to a more urban, more cosmopolitan type of thought.

Depressions of the 1930's and 1870's Similar

A series of striking parallels can be set up between the depression of the 1870's and that of the 1930's. In both instances a great war had strained both the material and the moral resources of the country, to be followed by a brief period of illusory prosperity in the industrial and mining regions and in the grain belt. With the collapse of prosperity came the same derangements of money and commodity values, the same train of unemployment, business failures, bank crashes, conflict between debtor and creditor classes, and bitter personal hardships. Politically, one notes the same struggle for control between the executive and the legislative arms of the government. It is easy to press the parallel beyond sound logic; but the severity and length of the present crisis, as in the 70's, tend to make far-reaching readjustments fairly inevitable.

The upthrust of industry that followed the depression of the 1870's was due in large measure to power, fuel, and metal, as limitations of supply rapidly were overcome. The entrance of electricity into the realm of industry did for power what the invention of money had done in the early days of civilization for commerce. With water power or steam alone only direct barter was possible; electricity supplied a circulating medium, infinitely flexible, capable of aggregation or subdivision, and easily transported to distant points. As yet, one searches the horizon with uncertainty for some major technical advance that will do for the 1930's what the coming of electricity did for the 1870's.

Written especially for ELECTRICAL ENGINEERING, based upon an oral presentation before the A.I.E.E. New York Section, April 28, 1933. *Not published in pamphlet form.*

Will it be aviation, or television, or air-conditioning, or light high-strength alloys, or synthetic substitutes for natural raw materials? At the moment, no one or even all of them seems to have quite the lifting power needed to get industry out of the trough.

Be that as it may, underlying conditions now, as then, seem to point to the coming of a distinctly new epoch. The recent one was marked by rapidly expanding production and rapidly rising population. Agricultural production per capita has been at an apparent limit of expansion for 30 years or more. In the same period the mineral industries multiplied their output relative to population by $2^1/_2$ and the manufacturing industries by $2^1/_4$; both, it appears, have increased their productive capacity in an even greater ratio than their output, and are possibly within the border land of actual overdevelopment. Potential or actual shortage of man-power, which has been the mainspring of invention and of management technique in American industry, seems permanently to be overcome. The late war marked a turning point in capital supply. Throughout the last century we were importers of capital and exporters of goods, the outflow of surplus products of our farms, mines, and mills needed to balance the income account reaching an excess of $600,000,000 annually over our imports. The war reversed matters, and we should need to accept an excess of $1,000,000,000 in imports annually in order to receive 4 per cent on our loans abroad. The tariff dam which was built to insure our excess of exports under pre-war conditions now shows signs of being obsolete, if not actually an obstruction.

Our unparalleled rise in population, which in the middle of the last century was proceeding at 20 times the highest average world rate ever before recorded, now appears to be checked. Resource valuations built up on anticipated scarcity have been deflated; and industry may not be able for a time to prosper by its own expansion, borrowing against the future to expand its plant and converting the expenditure into added purchasing power for its current products. Our natural resources are now quite accurately known and almost fully preëmpted. Quick riches no longer awaits the first man to discover and exploit nature's bounties. The country is settling down to the long-scale use rather than the hasty squandering of ore, coal, timber, and soil, and presumably soon will reach that stage in oil as well.

Present Transition Involves Social Changes

The present transition is not only economic, but also social as well; and it may be expected to result in significant changes in our political system. The goal of the pioneer's striving was self-sufficiency. To get on meant to acquire land, bring it under cultivation, escape debt, manage with the labor of one's family, and supply one's own need as fully as possible —in a word, to become independent. To a population of which 10 in 11 persons lived on the soil, as did the American people of 1790, that government was best which governed least. Interests were intensely parochial; and school, church, and government were to be as much as possible local institutions. Men feared centralization as an enemy of liberty and looked to the principle of local representation to safeguard their vital interests. Modern life, with its industrial and urban setting, tends to magnify corporate interests over purely individual interests. Men's occupations and their economic connections have become more significant indices of their vital interests than any mere locality. In the modern world men largely prosper or fail as groups. Farmers, coal miners, and bank depositors may be down, while brewers, tire-makers, and annuity holders are up. The sea and the frontier no longer stand as guarantees of individual opportunity when adverse circumstances hem one in. The government which governs least, is not necessarily best, nor perhaps even possible. Rugged individualism is giving way before a broad socializing movement in which such nonpolitical bodies as trade organizations, professional guilds, labor unions, mutual insurance and savings associations, and farm coöperatives are becoming the actual functional units of our common life.

Conditions Foreshadowing the New Deal

To summarize, the altered conditions which foreshadow the new deal are: (1) adequate capacity to produce, with the use of barely $^1/_3$ of the population to supply material necessities; (2) the stabilization of population with an altered scale of resource valuations and a lower pace of industrial expansion; (3) the reversal of our international economic position from debtor and exporter, to creditor and, in prospect, importer; and (4) the growing ascendancy of corporate over individual interests, and of functional over political interests.

Social readjustments to these altered bases of national economy now are beginning to take form. Apparently a new balance is to be struck between agriculture and industry. Lowered costs and higher unit production have failed to make the farmer prosperous in the face of market limitations. The engineer and the chemist now may be called to his aid in order to broaden the industrial outlet for his products and to by-process his waste materials. A wider distribution of industry through the agricultural areas would make for rural prosperity, and aid in striking a new balance between city and country living. Cities, in their more congested forms, are largely products of technological forces which engineers are now able to reverse. When only animal, water, or steam power were available, the worker had to come to the power. With only water and rail transport for heavy commodities, industry had to seek the traffic arteries. Without universal electrical communication, concentration in one site was essential to executive control. Now, all these limitations are overcome and the centralizing movement in industry appears to have passed its peak. Rural areas are fast approaching equality with cities in sanitation, comfort, and cultural opportunity. If the land through some combination of soil and job is to serve as a shock absorber for the annual and cyclic irregularities of industrial employment, a wholesale redistribution of industrial population may result.

Little Has Been Done to Advance Consumption

The striking of a new balance between consuming and producing power inevitably will carry with it a new valuation of goods, economic security, leisure, recreations, and cultural opportunity as the rewards of human effort. Under an economy of scarcity, the assumption that men's material desires and their consuming power might be expanded indefinitely, was a justifiable working principle. Under an economy of abundance, this principle may not necessarily hold good. In a society where only 3 persons in 10 are concerned directly in producing physical goods, men must expect to take a considerable return of higher productivity in intangible forms. Until now, nearly the whole weight of finance, research, and education has been put behind the effort to increase production. Except for the seductions of advertising, little has been done to advance consumption or to raise it to a scientific level. Directly or indirectly, the scientific worker of tomorrow may have to look more largely to the consumer for employment.

The new balance that is to be struck between our internal and our international economy bids fair to bring our historic tariff policy to a natural end. If the American employer and worker no longer are sheltered by a tariff wall, they may need to depend more on the protection of technical superiority, such as American engineering and mass production already have given to the automotive industry.

The protection that employer and worker may desire is likely to be quite as much against uncontrolled technological changes as against foreign competition. The risk of supersedure without warning has become one of the nightmares of industry. Economists agree that permanent technological unemployment is impossible, but the hardships of transitional unemployment are known to be severe and apparently are increasing. The ideal solution would seem to lie in the direction of increased fluidity in consumption and in the use of labor, rather than any checks or burdens on research, invention, and improved technique. Constructive readjustments of this kind are harder to achieve, as a rule, than regulative or restrictive measures. It is easier to slow down technological changes, by cutting off patent privileges, or by burdening industry with dismissal bonuses or unemployment insurance, than to induce the public to adjust itself more quickly to new forms of consumption that will absorb a surplus of labor supply without undue delay.

Public Works as a Regulator

A new balance is to be struck between public enterprise and private industry. The most promising corrective which has been suggested for the cyclic variations of industry is to use the construction of public works as a regulator or compensator. When private industry slackens, it is proposed to increase the construction of public projects under a long-scale plan, and to reduce such construction as industry recovers. A new balance is to be struck also between private initiative and public regulation. It is probably neither desirable nor practicable to apply the regulatory powers of government to the individual business or concern. Self-governing groups within industry, working under a code of fair and unfair practices and under some umpiring system sanctioned by the government, seem likely to assume an increasing importance. In short, we may expect to see a type of government based upon industrial and occupational interests growing up alongside of our present government based upon geographical and political interests.

A new balance is to be struck between realistic and idealistic forms of education. Young people are becoming relatively more scarce and adults of later maturity more numerous in our population. In the past century the age group above 50 has risen almost 4-fold relative to the group under 20. Leisure is being transferred from youth to maturity. Young people come from school to face a world of work with thousands of highly specialized occupations against which they must match their powers and interests, while their elders increasingly must find activities in the cultural realm if they are to be occupied at all. The answer appears to be a much more realistic effort in the high school to fit young people efficiently into the world's work, and the transfer of much of our national effort to create a distinctive culture to the realm of adult education.

A New Balance Between Utility and Beauty

Finally, we may expect a new balance to be struck between utility and economy on the one hand, and convenience and beauty on the other. Engineers need especially to take to heart the changing scale of values. Too readily have we taken it for granted that a city where steel is made must be ugly with grime; that a meat packing city must expect to be overspread by a sickening odor; that a coal mining region is supposed to miss sweetness and light; that if trains operate cheaply and are fast and safe, one must expect them to rattle and shriek, to vibrate and jolt. We engineers need to remind ourselves that an intense preoccupation with utility and economy is characteristic of a pioneer civilization, struggling to acquire its bare necessities and to accumulate capital to get ahead; and that large areas of American life have passed into a more mature phase of development.

Epochs in our history have formed and reformed around a sequence of characteristic social urges—the urge to escape from the limitations of the old world, the urge to attain self-sufficiency, the urge to expand, and the urge to multiply goods and wealth. He can best forecast the new deal who can most clearly foresee the dominant urge of the next 2 or 3 decades. The urge to produce is not dying, but it bids fair to be overshadowed by a rising concern over the distribution of wealth, not alone as goods and economic security, but also as intangible privileges of leisure, recreation, education, and cultural activity. Many expect to see our major efforts shift from the realm of technological pioneering into the realm of pioneering in social and economic relations. What has the engineer to gain or lose in such an epoch and what can he contribute to its making?

The Early American Engineer

Transition decades following the American Revolution called the technical professions into being, and the decade of the 1870's vastly enlarged their scopes and opportunities. It was then that engineers began to multiply and to organize along specialized lines, that scientific training got its first firm foothold. Schools of technology, of which there had been 6 up to 1860, increased to 62 by 1872. The curriculum was organized into parallel branches, laboratory and shop instruction was widely introduced, and a distinctive American technical literature began to appear.

The engineer of the early decades of the last century had been largely an individual builder of highways, bridges, canals, waterwheels, engines, textile machinery, and railroads. As a constructor, he was prepared to deal with nature and with men in the rough—a man who came, surveyed, planned, built, and went his way. As a manufacturer, he had no sense of professional caste or code. In either case, he was an intense individualist and a man of independent spirit. In the later decades events tended to curb this individualism and gradually to transform the engineer into a team-worker and an executive. With the consolidation of the railroads, the engineer began to take his place in corporate industry. An individualist might locate and construct a line, but another type of man was needed to weld separate units into an organic system and to plan systematically for its maintenance, betterment, and extension. The engineer found himself working with men and money, as well as with materials and machines. In the electrical industries the engineer took his place as an operating executive as well as a planning and construction specialist from the beginning. As manufacturing, under the influence of Taylor and his disciples, came to be conceived as a completely planned and integrated process based upon research, the engineer's function enlarged on the side of management. The intense individualism of earlier years had given place to a more collective philosophy; a growing consciousness of the profession as a corporate body was in evidence, and engineers began to pride themselves as being the vanguard of a sweeping movement to professionalize the entire direction of industry and of business as well.

The Engineer in Today's Changing Society

The historic rôle of the engineer has been to take guesswork out of construction and production by a blend of science and "horse sense," and to put self-interest in the background under a code of professional ethics and responsibility. The place which he will be able to claim in a changing society will depend on his ability to change with it, to bring new scientific resources to bear, and to broaden the area to which he applies his characteristic procedures. For example, the engineer has taken the guesswork out of the mining and cleaning of coal and its conversion into other forms of energy. Can he take guesswork out of the opening of new mines, regularizing working time, providing a decent living for workers, and insuring the economic use of fuel in its final conversion? He has taken guesswork from the design and manufacture of motor vehicles, but the selling costs remain disproportionate to the costs of production. How much guesswork can be gotten out of their distribution, the cycle of their use, and their final disposition? Do the styling changes on which the industry spends its feverish efforts actually stimulate or derange the market, in the light of cold analysis?

Engineering management aims to remove guesswork from the executive direction of industry. The old corner stone of authority was the word of the boss; the new one is research. The engineer as manager does not trust to tradition, which means the privilege of repeating the mistakes of one's grandfather; instead he seeks to rest decisions upon established laws, upon verified facts, and upon tested standards. Do such laws, facts, and standards exist as a basis for decisions which touch on social relations? Engineers have been inclined to answer "no" and to lift their eyebrows at the scientific pretensions of the several branches of social study. An open-minded reading of the 2-volume report of Mr. Hoover's commission on current social trends will give surprising evidence of the extent to which the social sciences have approximated a valid basis for social engineering. The engineer of tomorrow cannot afford to slight the study of history, economics, sociology, and political science, intangible though they may seem. Not only will they influence his social philosophy, but also they are fairly certain to change the premises upon which will rest his valuations, his calculations of annual costs and present worths, his estimates of useful life and earning power, his allowances for obsolescence, and his proposals for quick or long-range exploitation of resources.

Increased attention to the social premises of engineering does not imply that the engineer is to become a propagandist or a revolutionary. By nature and function, the engineer is not a social doctrinaire of any sort. He is a social pragmatist and a believer in evolutionary change—one whose "aim is to test all things and hold fast to that which is good." He will work within any social system, as far as it will work—equally in democratic America, in imperialistic Japan, in fascist Italy, and in communistic Russia. In a changing social order, a healthy pragmatism is a great asset. The doctrinaire risks the perils of disillusionment or even martyrdom for the possible ecstasies of triumph. The pragmatist has little chance to be acclaimed a prophet, but he is able to make quick adjustments without violence to his conscience or his personal loyalties. When the dust of revolution settles, he is usually on his old job of keeping the show going.

In an age of pioneer work on social control, the engineer seeking a larger place in the sun must look largely to the realms of management, distribution, research bearing on the use of products, the control of men, and the handling of organizations. He will be wise who best equips himself, in the words of Thomas Huxley, with "knowledge of men and their ways" as well as of "things and their forces."

Light Sensitive Process Control

Many industrial processes require accurate control of the concentration of solutions. Two regulator schemes for automatically controlling such concentrations are described in this article. Light sensitive tubes form the heart of these schemes.

By
J. V. ALFRIEND, JR. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

IN ORDER to keep certain electrochemical processes functioning within definite limits of tolerance without automatic control, it has been necessary, in some cases, to resort to close supervision by chemists who regularly sample the process liquors, determine their concentration, and take what corrective measures are indicated. This work can be accomplished by a skilled laborer under the direction of the chemist if there is only one variable and if this variable is responsive to colorimetric analysis either by the addition of an indicator or by its own color or opacity.

However, even this is expensive, slow, and inaccurate. The accuracy in the best of cases will vary with the health and fatigue of the analyst with the conditions of illumination, and with the pressure of other work. Furthermore the analyst must change the speeds of pumps, conveyers, compressors, etc., and either hope that the correction is sufficient or waste valuable time waiting for the correction to take effect before he can obtain a check sample.

Recent developments in the matching of colors, the measurement of the intensity of smoke, and the automatic control of illumination indicated that colorimetric process control might be obtained automatically by some modification of this new equipment which has proved commercially successful. Therefore a study was made covering the variables encountered in process control that should affect a light sensitive device similar to those just mentioned. A few applications where automatic control is definitely advantageous and where the variable chemical affects the shade or opacity of a liquor either directly, or indirectly by the addition of an indicator, follow:

1. In metal flotation the maximum recovery is possible over a very narrow range of hydrogen ion concentration. The addition of an indicator to a filtered sample is required to bring out the definite shade corresponding to the concentration. Both the filtration and the addition of indicator can, of course, be made automatic. The lime feed can then be controlled for a definite hydrogen ion concentration at the launder or in the flotation tanks.

2. In electrolytic reduction plants, close control must be exercised over the acid concentration of fresh electrolyte from the leaching vats, and the spent electrolyte from the electrolytic tanks in conjunction with the flow of make up acid if required by the process. The acidity of the waste liquors should at least be indicated and preferably regulated. Determination of hydrogen ion concentration by colorimetric methods and the control of pump speeds and electrolytic current flow will maintain the desired balance and give the necessary indications.

3. In electrolytic refining the best power efficiency is obtained at a definite hydrogen ion concentration, which is steadily reduced as the electrolyte increases in copper content. Control of this concentration by colorimetric methods affecting the speeds of the circulation pumps and the current flow in the stripping tanks will maintain the desired acidity.

Numerous other applications in the electrochemical field will naturally occur to those interested in such processes. As a matter of interest a short list is given below of applications outside the field of electrochemistry but which bear upon this problem.

1. In the recovery of the sand used in the washing of coal it is necessary to keep the percentage of solid matter in the waste water between specified limits in order to obtain maximum recovery. The opacity of a thin stream of the effluent liquid is a definite criterion of the per cent solid matter contained.

2. In municipal water plants using chlorination it is necessary to regulate the amount of excess chlorine. The addition of an indicator to a sample of such water gives a color corresponding to the amount of excess chlorine present.

3. In paper mills the acidity of the paper stock solution and the concentration of the black liquor must be closely controlled. The acidity of the paper stock solution can readily be determined by the addition of an indicator to a sample and the opacity of the black liquor is a function of its concentration.

Two concentration regulator schemes have been developed for these classes of service. The first or "balanced bridge" arrangement utilizes 2 light sensitive photoelectric tubes simultaneously to inspect the light transmitted through a sample of the unknown liquor and the light transmitted through a standard colorimetric sample representing the desired quantity of the variable chemical. The second or "null" method uses a single photoelectric tube inspecting simultaneously the light transmitted by the unknown sample and the known sample. The balanced bridge arrangement utilizes established light sensitive circuits assembled in such a way as to perform the new function. It has the slight disadvantage of requiring recalibration from time to time because of the possibility of discrepancies in characteristics developing with age of the tubes. No such recalibration is necessary with the null method because, as the term implies, the regulation effects a zero response from the equipment when the percentage of the varying chemical is correct. The advantage of the balanced bridge arrangement is that it can also be used as an indicator whereas the null method does not permit its use as an indicator without the recalibration which it is designed to avoid as a regulator. Otherwise the 2 schemes are very similar in economy, speed, and accuracy.

In Fig. 1 is shown a balanced bridge arrangement of photoelectric tubes designed to regulate the hydrogen ion concentration of a flotation liquor, by control-

Full text of "Light Sensitive Process Control" (No. 33-45) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.

ling the speed of a conveyer which feeds lime to the process and maintaining this speed constant between corrective impulses received from the photoelectric tubes. The schematic diagram is complete up to and including the motor drive for the lime conveyer. The mechanical equipment such as sampling, filtering, adding of indicator, and placing before the photoelectric tube are omitted because these features will change with individual applications. It should be noted here that only minor changes of the equipment shown in the diagram are required to make it applicable to the control of solenoid or motor operated valves or motor operated rheostats and similar equipment encountered in regulating the flow of solids, liquids, and gases.

The principle of operation is briefly as follows. Two photoelectric cells marked 7 and 8 in Fig. 1 are connected in a wheatstone bridge circuit which is supplied with direct current by a *B* eliminator. Potentiometer 1 constitutes one side of the bridge, and the 2 photoelectric tubes the other side. The 2 photoelectric tubes are illuminated from the same light source, not shown in the diagram. In front of one photoelectric tube is placed a standard color sample in a glass tube, while the fluid to be controlled flows through a similar glass tube in front of the other photoelectric tube. It is apparent that any variations in light intensity due to varying lamp voltage will not have any effect on the balanced bridge circuit. If the alkalinity of the fluid changes the bridge becomes unbalanced so that the voltage on the grid of tube 2 will differ from the grid voltage on tube 3. The result of this unbalance is that the grid of one of the 3-electrode gas or mercury vapor filled electronic tubes, 13 or 14, becomes more negative and the grid of the other tube becomes positive. Positive grid bias on one of these tubes causes a breakdown of the tube so that for example relay III will become energized and close its contacts. It should be noted that tubes 2 and 3 are connected in a wheatstone bridge circuit which is normally balanced. For this reason, variations in supply voltage will not affect the calibration of this part of the equipment.

When relay III operates, relay V is closed and seals itself in, and voltage is applied to tube 4 which, in combination with relay II, acts as a time delay device. Depending upon the adjustment of potentiometer 6 a time delay up to one minute can be provided between the instant of closure of relay V and the instant of closure of relay II. Relay V in closing also operates the motor-operating relay VII, which causes the motor operated rheostat to move and readjust the speed of the driving motor. Relay VII will remain closed until relay II is energized, since "break" contacts of relay II are connected in series with the coil of relay VII. During this period the motor speed is being readjusted.

When a correction has been made it is essential to prevent a second correction from being made until the effect of the first correction has been recorded by the photoelectric tubes. For this reason a second time delay relay is provided which may be adjusted for a time delay up to 5 min and which is so connected in the circuit that during this time interval no rheostat operation can take place. This second time delay relay consists of relay I, tube 5, and associated equipment. It will be noted that the timing of this combination starts with the closure of relay II. When relay I operates, relay V will be deënergized, and the equipment will be ready for the next adjustment.

Supposing the standard sample is arranged in front of photoelectric tube 8, a recalibration of the equipment may be made either by changing the standard sample or by adjusting potentiometer 1. The instrument should be calibrated by opening switch 9, and connecting a high resistance voltmeter across resistor 10, by means of telephone jacks supplied for this purpose. Potentiometer 11 is then adjusted until the voltmeter reads zero.

The sensitivity of the regulator may be adjusted by means of potentiometer 12 which changes the

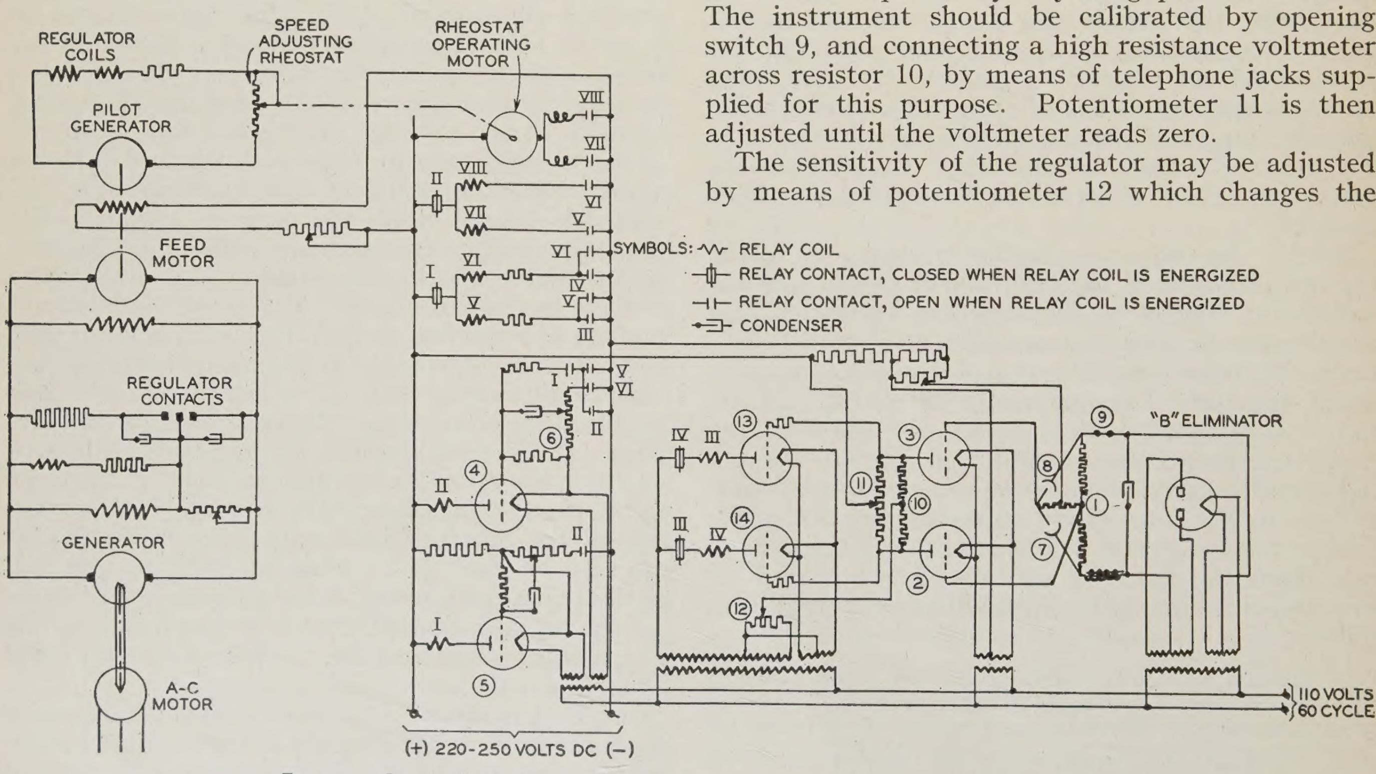


Fig. 1. Circuit for balanced bridge type of concentration analysis regulator

constant negative grid bias which is applied to tubes 13 and 14.

Proper operation of the electronic regulator described above is predicated upon the requirement that the motor operating the feed runs at the definite speed dictated by the regulator. These speeds must be maintained at the level indicated by the regulating equipment and not be permitted to vary from the dictated amount. Small motors do not possess flat speed-torque characteristics, particularly at varying armature voltages. Therefore, speed regulating equipment is added to the motor driving the feed.

The apparatus shown at the left in Fig. 1 is this speed regulating equipment. The lower motor-generator set provides the armature voltage for the feed motor. This motor itself has coupled to it, a small pilot generator which will be excited from the 250-volt d-c supply. The voltage of the generator supplying the armature of the feed motor is regulated by a voltage regulator. The coils of the regulator are connected across the armature of the pilot generator in series with the motor-operated speed-adjusting rheostat.

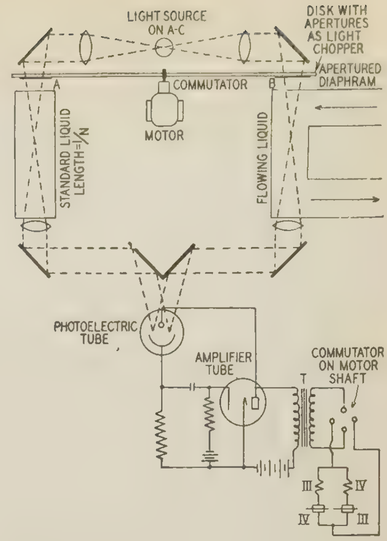
The functioning of this speed regulating equipment in conjunction with the electronic equipment is as follows. Assume the regulating equipment to be in operation and the fluid being regulated to be of the proper color. Now assume that the color of the regulated liquid changes. As outlined in the preceding paragraph, this change will result in the operation of the motor controlled by relay VII or VIII. This motor is located on the speed adjusting rheostat which modifies the current through the regulator coils connected across the pilot generator armature. The result of the movement of this rheostat is to change the calibration of the voltage regulator which in turn modifies the voltage delivered by the generator of the motor-generator set and in turn raises or lowers the speed of the motor driving the feed. The action of the voltage regulator is then to keep the speed of this motor at the newly chosen level until a new speed is dictated by the action of the speed adjusting rheostat as directed by the electronic regulator. The functioning of the voltage regulator at any selected value of speed is such as to keep the motor operating at the desired speed without the minor fluctuations which are inherent in such motors.

Operation of Null Method

As previously mentioned the null method was designed to eliminate the necessity for recalibration involved in the balanced bridge arrangement. Both arrangements equally flexible in regulating hydrogen ion concentration or opacity of a given solution by controlling the feed of the variable constituent. In Fig. 2 is shown the null method photoelectric tube circuit which is interchangeable with the balanced bridge circuit shown as part of the diagram in Fig. 1. For a colorimetric regulator either photoelectric tube circuit may be used, with the same timing and speed regulating equipment shown in Fig. 1, relays III and IV being the same in both figures.

Briefly the null method regulating equipment operates on the following principle. The light beams from a single light source are directed by a system of mirrors and lenses through 2 different paths onto a single photoelectric tube in such a manner that one beam passes through a standard color sample and the other beam passes through the unknown liquid. An apertured diaphragm is rotated in the path of the 2 beams so as to vary the cross-section of the beams permitted to pass through the 2 liquids. The sum of the apertured areas A and B is always equal to unity, the aperture A varying from zero to 100 per cent while the aperture B varies from 100 per cent to zero.

Fig. 2. Circuit of null method of concentration analysis regulation



Thus if the light transmitting qualities of the 2 liquids are identical the illumination of the photoelectric tube will be unchanged as the diaphragm is rotated, and therefore the output of the amplifier tube or its plate current will be constant direct current. With constant direct current impressed on the primary of transformer T there will be no output from the secondary, and relays III and IV will not be energized.

If the light transmitting quality of one of the liquids deviates a small amount from that of the other the illumination of the photoelectric tube will vary as the diaphragm is rotated and the plate current of the amplifier tube will therefore become a pulsating direct current. With pulsating direct current impressed on the primary of the transformer T the secondary will deliver only the alternating component, which in phase position and in magnitude will be proportional to the deviation in light transmitting qualities of the unknown fluid from that of the standard fluid. Since this alternating component is rectified by a mechanically driven commutator on the shaft of the motor which drives the diaphragm, the direct current obtained will be proportional in sign and magnitude to this same deviation in light transmitting quality. With relay III set to pick up at a minimum value of positive current, and relay IV set to pick up at a minimum value of negative current, the speed adjusting rheostat and timing cycle explained under Fig. 1 will be set in operation just as these operations were started when relays III and IV of Fig. 1 were energized by the breakdown of tubes 13 and 14.

Since this circuit is a zero or "null" method and this feature is obtained by filtering out the direct component of the plate current of the amplifier tube, the regulator is insensitive to steady variations in applied voltage as affecting the circuit or the light source, and it is not affected by steady variations in temperature or changes in sensitivity of the tube itself within its working range.

Conclusion

The concentration regulator schemes presented provide the accuracy, reliability, and economy required of such devices. In addition they provide an adjustable amount of correction for each sample observed, together with an adjustable inoperative time while awaiting the effects of one correction. Thus the equipment as designed may be applied to a wide variety of uses with the major problem being only the manner in which the unknown sample is prepared and placed before the eye of the photoelectric tube.

Engineering Schools and the Changed Conditions

How are American schools of electrical engineering to adapt themselves to changed conditions in industry? According to this well-known engineering educator "an analytical scholarly faculty is the key." A rather thoroughgoing reform in methods and contents of engineering instruction is believed inevitable.

By
VLADIMIR KARAPETOFF
FELLOW A.I.E.E.
Cornell Univ., Ithaca, N. Y.

During the decade preceding 1929, schools of engineering in the United States became fairly well adjusted to prosperity conditions in industry, conditions which no longer exist and whose return is highly improbable for several years to come. Moreover, thousands of engineers now unemployed will have to be absorbed in various occupations before there will be a ready market for future engineering graduates. Consequently, engineering educators cannot go on as of old, teaching and preparing young men for various specific activities for which now there is practically no demand; they may just as well train them for warfare with spears and arrows.

Among the teachers of electrical engineering recruited or promoted since the World War there still are some who have been useful mainly in turning out graduates in comparatively large numbers, training them in routine electrical computations and testing, and drilling them in the elements of neatness, cooperation, and professional honesty. Some of these teachers were engaged during the "sellers' market," when the schools had fewer applicants for instructorships than there were vacancies. For them, too, the situation has changed, for now it is distinctly a "buyers' market" with a vengeance.

A rather thoroughgoing reform in the methods and contents of engineering instruction inevitably is impending; the alumni and backers expect engineering colleges not only to follow this trend, but also to lead and to show the way in the forthcoming reconstruction. What to do with teachers who in the last few years have considered their jobs merely as "soft berths" until something better turns up, is a problem that must be faced squarely by themselves and by the rest of their respective faculties. The problem is not so serious for younger men who did not expect to stay in the teaching profession anyway. It may become serious for those who complacently have settled down to do elementary teaching for the rest of their lives in the same routine way, interspersed with simple administrative duties. Some of them have done this without any regard to the progress of the art or to the standards of productive and creative scholarship expected in their positions and commensurate with the high standings of the colleges with which they are connected.

Unless a new epoch-making invention or discovery, capable of immediate practical application on a large scale, points the way of reform, instruction will have to be changed from superficial applications to thoroughgoing fundamentals, and from supervised drill in details to an inspired leadership in definite trends of the human mind. From preparing nice boys greased for groping with a minimum of friction through the alleys and byways of a large corporation, the colleges must turn to shaping men of vision, capable and eager to open new avenues through which their successors will march toward rebuilding this country in accordance with new social ideals.

In the old situation, almost every suggestion for an improvement in a college of engineering could be met with the conciliatory refrain: "yes, if we had sufficient funds." In the forthcoming shake-up and reform, a shortage of funds will play no significant part. Schools will need fewer teachers, will not have to pay any higher salaries to those employed, nor in general need any larger or more expensive buildings and equipment than they now have. The reform is to be almost purely mental, similar, say, to the decision of a church congregation to change from one Protestant creed to another. Even the hymn books

Based upon an address presented at the A.I.E.E. North Eastern District meeting, Schenectady, N. Y., May 10–12, 1933. *Not published in pamphlet form.*

and the collection plates may not have to be changed.

The key to the change lies first and last with the faculties of the colleges. Educators need not and should not wait to be told by the "powers that be" that there is a depression and that they ought to figure out some way to adjust their methods of instruction and the contents of the courses to what is coming. It is to be hoped that a group of young instructors, not yet 30, will take the lead and inspire the rest. Not that all educators shall fall at once on the necks of these reformers and sob out an acceptance of their ideas, but if this group is to consist of real leaders, capable of hardening under the opposing forces of inertia and resistance, their influence eventually will triumph.

Present courses of instruction soon will become vitalized in their contents, and lectures will ring with a new call—a call for fearless analysis of the fundamentals, technical and otherwise, and an appeal for creative work along new paths, be it in human engineering or in electronics. Furthermore, it will not be long before the bulk of the profession will look to this group and to the schools of electrical engineering for guidance and light.

The only word of caution that the author has to offer is this: New leadership in engineering education must be based upon true profound scholarship and not upon the hot air of a catchy phrase or some pious wish which for a while sounds plausible. Ever since Socrates, Plato, and Aristotle gloriously led their disciples, no substitute has been found for real analytical productive scholarship in colleges and universities. For a while engineering colleges tried to substitute for it the teaching of "actual practical methods"; then they sought an alibi in carefully laid-out formal (and formidable) curricula, schedules, petition committees, printed forms, mimeographed instructions, and what not. Inefficiency and ignorance covered up by good fellowship and pipe dreams, non-resident lectures by uninteresting practical men, almost anything was tried to circumvent the straight narrow academic path which leads back into the fundamental laws of nature (including those of our minds) and which leads forward to a realization of the best ideals of teaching, research, and industry.

Long mathematical formulas are but symbols of unavoidably involved relationships behind them, and a teacher who always has had difficulty with formal mathematics or theoretical physics is just as likely to become entangled in an experimental investigation containing several conflicting factors, in the real economics of the present complex world, or in sales management and distribution of a product in the midst of cut-throat competition. Everywhere it is powerful analytical reasoning, culminating in a new relationship, that characterizes a worthy university professor no matter what he teaches. Unless and until a school of electrical engineering has a group of such men as a nucleus of its faculty (preferably among the younger men) any attempt at reform or rejuvenation of the ailing electrical world will be just another expansion into a vacuum. An analytical scholarly faculty is the key!

Editor's Note: For a discussion of this article see p. 647, this issue.

A New Method of Starting an Arc

Attempts to initiate an arc cathode upon a cold electrode within a very short time interval and in a gas at low pressure resulted in the development of an unusual igniting device. The possible applications of this device are many and include the control of gas filled electronic tubes, eliminating many of the problems associated with the use of grids.

By
J. SLEPIAN
FELLOW A.I.E.E.

L. R. LUDWIG
ASSOCIATE A.I.E.E.

Both of Westinghouse Elec. and Mfg. Co., E. Pittsburgh, Pa.

THE ELECTRIC arc is an essential element in many types of engineering apparatus, due to its ability to carry large electrical currents with a potential drop of only a few volts. The origin or seat of this capacity resides quite definitely at the cathode, and in fact, it is only at the cathode that the arc differs essentially from other types of self-maintaining discharges. The problem of the formation of an arc then reduces to a study of its cathode, and the circumstances which favor the formation of such a cathode. The problem with which the authors have been concerned was the frequent repeated initiation of an arc cathode upon a cold electrode within a very short and precisely placed time interval of less than 0.001 sec, and in a gas at low pressure. The known methods for the ignition of a cathode spot were found to be inadequate to satisfy the stipulated requirements.

New Arc Starter Developed

In attempting to develop an igniting device of the type required, it was discovered that a rod of relatively high resistivity partly immersed in mercury had very extraordinary properties with respect to the initiation of arc cathodes on the mercury surface. The first observations were made on a carborundum crystal. It was found that about 10 amp flowing through the crystal would start an arc cathode, and unlike the tungsten rod of previous experiments, this current magnitude for starting the arc cathode varied

Based upon "A New Method of Initiating the Cathode of an Arc" (No. 33-23) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933. Essentially full text of that portion of the paper which discusses the new starter is included.

very little with the degree of immersion of the crystal. The voltage required for starting varied with the length of the crystal above the mercury and was less than 100 volts for moderate lengths. The starting of the arc was extremely regular and reliable. An oscillogram of operation of a mercury pool cathode vapor tube with such a starter is shown in Fig. 1. The starter electrode was connected to the anode of the tube through an auxiliary external rectifier, and the whole was placed in an a-c circuit. As will be seen from the oscillogram, in each half cycle of polarity proper for sending current through the external rectifier, an arc was started in the tube.

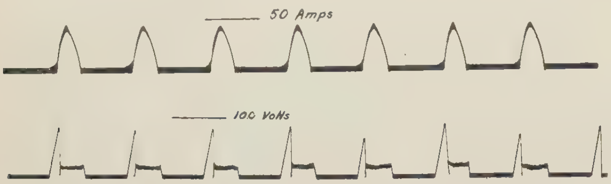


Fig. 1. Reproduction of oscillograph showing instantaneous voltage and current of igniting electrode

This extraordinary property for starting an arc cathode was found to be generally enjoyed by materials of considerable resistivity. Thus similar results were obtained with starter rods made of lightning arrester resistor material (clay, lampblack mixtures), globar resistors (special carborundum heating elements), galena, and ferrosilicon.

No wasting away of the starter rods could be observed even after long periods of operation. Some rods on life test have now been operating 60 times per second, 24 hr per day for over 7 months with no observable deterioration.

The mercury pool was not an essential element in the operation of the starter, as regular operation was obtained with a starter rod partly buried in solidified tin, as well as with a molten tin cathode. Operation was obtained also in air at atmospheric pressure.

The time required for the formation of the arc cathode after the application of the necessary voltage was found to be extremely short. This was investigated with the cathode ray oscillograph, and it was found that 250 volts when suddenly applied to a resistor rod $^1/_8$ in. in diam and extending $^1/_2$ in. above the mercury, would initiate an arc within less than 5 microsec. As the voltage was reduced, longer time delays between the application of the voltage and striking of the arc were observed. These times varied considerably in test repetitions. In Fig. 2 is shown the average variation of the mean time with voltage.

Observations Bearing on the Theory of the New Starter

The insensitivity of the new starter to the degree of its immersion in the mercury indicated that its operation did not depend upon an actual breaking of contact with the mercury. This is confirmed by the operation of the starter buried in solidified tin, and it was also confirmed by operation obtained where permanent electrical contact below the surface of the mercury was insured by means of a tight metal clamp, and also by a copper sprayed portion of the rod below the mercury surface.

When operated just below the voltage required for regular operation, frequent tiny sparks would be observed at the mercury-rod junction. This suggested that the seat of the phenomenon resided at the mercury-rod junction, and also suggested that the operation might take place in roughly 2 stages, each stage setting different requirements. First would be the starting of a tiny arc cathode, the tiny sparks observed above. This would call for a very high electric gradient, or very large concentration of energy to effect a thermal explosion at the mercury-rod junction similar to what occurs at the last contact point of separating contacts. Second would be the building up of the small current flowing from this tiny arc cathode to an arc current sufficient to short-circuit the rod to the holder or another anode. This would call for the ability of the side of the rod immediately adjacent to the tiny "spark" or arc cathode to carry considerable current as the anode of an arc.

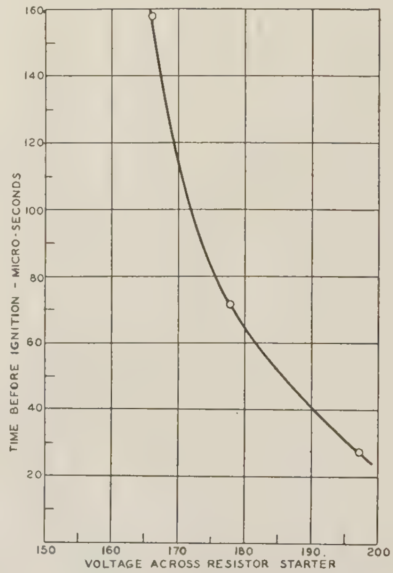


Fig. 2. Variation of mean time for ignition with different voltages

Both of these requirements seem to call for the existence of an electric gradient down the rod to the mercury-rod junction. The necessity for such a gradient is beautifully illustrated by some experiments of L. Smede.

As illustrated in Fig. 3, a hollow cylindrical starter made of globar resistor material was used. Good contact with the internal surface of this cylinder was made up to a level B by means of an amalgam. The electrical connection to the amalgam was brought in under the mercury and of course was insulated from the mercury. A barometric connection permitted the mercury level to be raised and lowered. The voltage required by the starter for regular operation was observed for different levels of the mercury. The results are shown in Fig. 4.

The impressed potential existed between the in-

ternal amalgam and the external mercury. When the mercury level was considerably below B, there would be current flow down the cylinder to the mercury from above, and, therefore, a gradient down the starter to the mercury. As the mercury level approached close to B, more of the current would flow across the cylinder wall to the mercury junction, and less down the cylinder wall. Hence for a given voltage the gradient down the rod would be lessened. Hence if a gradient of a definite magnitude is necessary down the starter at the junction, the voltage required for starting should rise rapidly as the mercury level approaches B. This, the curve of Fig. 4, shows to have been actually the case.

Theory of the New Starter

These observations suggest that with respect to voltage and energy concentration, conditions at the starter rod mercury junction must be similar to those occurring at the last contact point of separating contacts. Electrostatic theory shows that this is the case.

From the mathematical formulas of Maxwell, the potential gradient along the starter side near the mercury junction is calculated to be:

$$\frac{dV}{dx} = \sqrt{\frac{d}{2}}\frac{X_\infty}{\sqrt{x}} \tag{1}$$

where d is the thickness of the slab, X_∞ the gradient along the slab far from the junction, and x the small distance from the junction at which the gradient $\frac{dV}{dx}$ exists. According to this formula, the gradient, and with it the current density becomes infinite at the junction where $x = 0$.

Of course, eq 1 may be considered as applying only as close to the junction as the material may be considered continuous. If it is assumed that the material may be considered continuous down to atomic distances, that is, down to $x = 10^{-8}$ cm, and if the slab thickness is taken as 0.5 cm, the gradient at the junction is

$$\frac{dV}{dx} = \sqrt{\frac{0.5}{2}}\frac{X_\infty}{\sqrt{10^{-8}}} = 0.5 \times 10^4 X_\infty \tag{2}$$

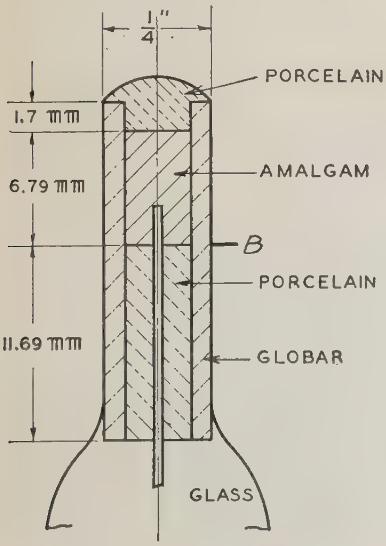


Fig. 3. Diagrammatic sketch of apparatus used to illustrate the necessity of a voltage gradient for ignition

If the appearance of a gradient of 10^6 volts per cm at the junction be adopted as a criterion for the starting of an arc cathode, the gradient, remote from the junction, is

$$X_\infty = 200 \text{ volts per cm} \tag{3}$$

Actually, less than 100 volts per cm were sufficient for starting an arc cathode with the materials tested. It seems likely that other phenomena peculiar to the carrying of current across contacts appear also at the junction, such as transition films of high resistivity, or the drawing up of small particles forming bridges, as suggested by R. Holm (see *Wiss. Veröeff. d. Siemens-Konzern*, v. 10, 1931, p. 1–19).

The first requirement for the starting of an arc cathode at the junction then seems to be the impressing of a gradient of the order of 100 volts per cm along the starter rod. This practically sets a lower limit to the resistivity of the rod material, since with ordinary metals and reasonable rod dimensions, the current required to maintain such a gradient would be enormous. Perhaps 10^{-2} ohms per cm³ may be set as the practical lower limit of resistivity of a starter rod of reasonable dimensions.

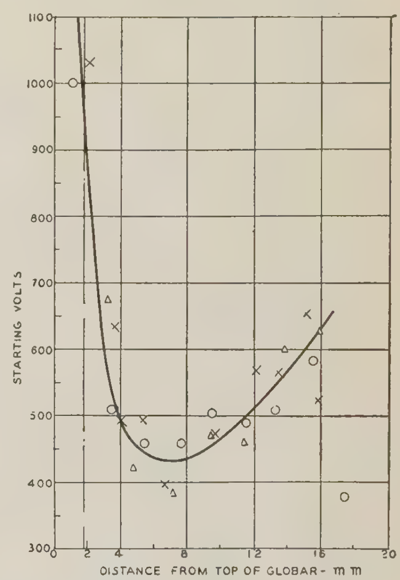


Fig. 4. Variation of ignition voltage with length of igniting electrode

The requirements of the second stage of the formation of the arc, however, set an upper limit to the resistivity of the rod. The tiny arc which forms at the junction must grow to a magnitude sufficient to short circuit the rod. Since the tiny arc first flows to the rod side as anode, the resistivity of the rod must be low enough to permit the flow of sufficient current through the rod side without requiring excessive voltage. Actually, it was found that the voltage required for starting increased with the resistivity of the rod material. A few thousand ohms per cm³ may probably be set as the upper limit for the resistivity of the starter rod.

Applications

Applications of the new starter will be obvious to those familiar with grid controlled gas tubes. In

such tubes, until now, an arc cathode was permanently maintained by a separately heated thermionic cathode or a keep-alive arc. The starting of an arc to a main anode was then controlled by a grid. Now the permanent arc cathode and control by the grid may be eliminated, and the starting of the arc to the main anode effected and controlled entirely by the new starter. Thus many of the problems associated with the use of grids, particularly for large currents, are completely eliminated.

New Pin Insulators Free From Radio Interference

Electric power transmission lines employing ordinary pin type insulators may cause radio interference although otherwise in good operating condition. With more than 13,000,000 radio receiving sets in the United States the seriousness of this problem is at once apparent. Accordingly, several manufacturers have developed insulators that are claimed to be free from interference at their rated operating voltages. In this article comparative tests on some of these insulators are described and the relative merits of the different designs are pointed out.

By
H. H. BROWN
ASSOCIATE A.I.E.E.

Chairman, Overhead Systems Committee, Wis. Utilities Assn.

RADIO broadcasting has brought about a new engineering requirement for electric power transmission lines, namely, radio interference proof design. Not only are mechanical and insulation design features essential but also non-radio interference designs are important. Present transmission lines employing pin type insulators are known to radiate through the territory they pass, a radio noise known as "transmission fry." Since the 1930 federal census revealed that there are 13,478,600 radios in the United States, engineers must realize the importance of quiet transmission lines. When television has been developed more fully, interference will be of even greater significance. However, with the extremely supersensitive sets on the market advertised with a set sensitivity "of better than $^1/_4$ μvolt per meter" it behooves all engineers to recognize seriously the influence transmission lines have on satisfactory radio reception. Radios are here to stay and the individuals responsible for registered complaints of interference along transmission lines for which no remedy has been found, may profit by learning of some of the recent insulator developments.

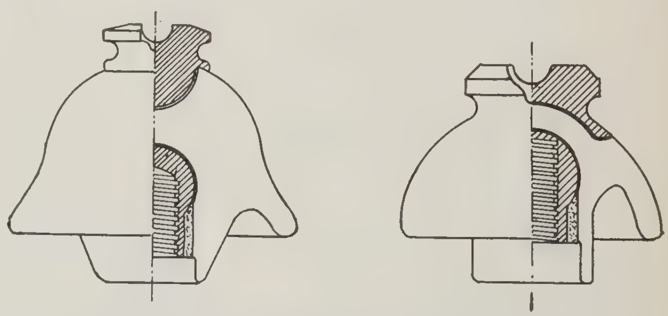
Excerpts from a report of the overhead systems committee of the Wisconsin Utilities Association, Milwaukee, Wis., presented at the annual section convention of that association, Appleton, Wis., Sept. 30, 1932. *Not published in pamphlet form.*

Standard Pin Insulators Require Alteration

Laboratory tests have indicated that many present pin type insulators for lines of 13.8 kv and higher cause radio interference. Field tests and observations have revealed that this interference is particularly annoying in territories remote from broadcasting stations where receiving sets often must operate at full volume to bring in the programs. Unfortunately, as a result, interference is increased in volume as well as the desired program.

To cite a specific example, tests show that with a standard one piece 13.8-kv pin insulator, interference begins at 6 kv to earth. The normal operating voltage to earth for such a line is 7.6 kv. Improvements in design have bettered the performance of the insulator so that radio interference does not begin until the voltage to earth is 24 kv. The new design for this unit is therefore far superior to the present design.

Radio interference voltages for the common ratings of present pin type insulators are tabulated in Table I; normal operating voltages to ground also are shown.



Figs. 1 (left) and 2 (right). Theoretical design of porcelain insulators with balanced electric stresses

In each of the present units the radio interference point is lower than the operating voltage to ground. Even though a transmission line be constructed with the best of materials and practice, it is apparent that radio interference will be present. However, new improved pin type transmission insulators have a

radio interference value which is claimed to be free from trouble.

Features desired in a radio-interference-free pin-type insulator are briefly as follows:

1. The radio interference voltage (corona voltage) should be higher then the normal operating voltage to ground so that a reasonable radio factor of safety prevails.

2. The principle employed in a new design should be practical and simple and should not destroy in any way present accomplishments in the insulator art.

3. The new unit should be capable of weathering the elements indefinitely.

4. Arc flashovers should not destroy permanently the effectiveness of the insulator from a radio, a mechanical, and an electrical viewpoint.

5. The new design should apply readily to present pins and cross-arms.

6. Simple and low cost tie connections for holding the line conductor should be possible.

7. Cost of the new unit should not be much more than that of present units.

8. The design should readily permit rains to clean the insulator or in certain cases permit the insulator to be cleaned easily by manual labor.

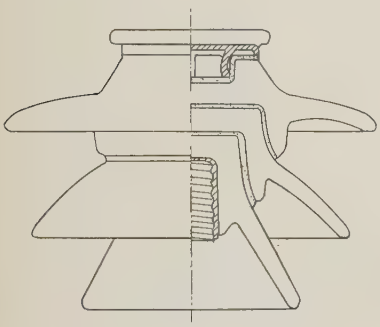


Fig. 3. An insulator of practical design with balanced electric stresses

Table I—Comparison of Normal Operating and Radio Interference Voltages for Standard Pin Insulators

Catalog Rating, Kv	Operating Line Kv	Normal Kv to Ground	Radio Interference Point (Kv to ground)
20	13.2	7.6	6.0
35	33	19.1	8.0
44	33	19.1	9.0
44	44	25.5	9.0
66	66	38.1	9.5

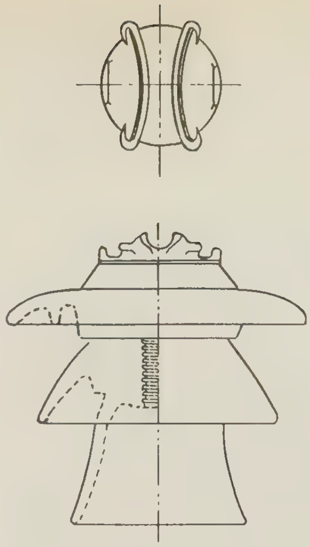
9. If portions of the insulator accidentally become broken off, the insulator should be able to continue in service without causing radio disturbances and without electrically or mechanically jeopardizing the line.

10. Charging current should not be excessive.

A few companies now have units in which they have endeavored to incorporate all these desired features.

New Interference Proof Pin Insulator

Even though research work has been restricted during the last few years, large porcelain manufacturers have placed on the market new radio interference proof pin type insulators. One large insulator manufacturer has applied a principle in new units that evenly distributes the electrical stresses, so that no breakdown or corona develops at the line conductor or at the tie wire. Theoretically, the design approximates equipotential surfaces between the line conductor and the pin. The first experimental units provided an ideal arrangement, as shown in Figs. 1 and 2, by distributing the stresses at the line conductor and at the pin. Later developments, however, proved that the spherical arrangement at the pin was not entirely essential for producing the desired results. Also slight additional alterations were made for mechanical and manufacturing reasons. Larger sized porcelain insulators necessitated multipiece designs as shown in Figs. 3 and 4. The upper portion is metal and the portion at the pin hole is a zinc thimble. Corona formation from the tie wire and line conductor is eliminated at normal voltages by means of the specially designed metal head. The height of this head also is designed so as to keep the cantilever pull at a minimum.



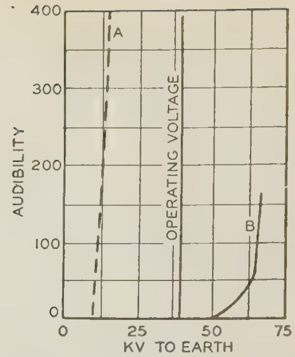


Fig. 5. Audibility curve (B) for a 66-kv unit of the type shown in Fig. 4 compared with that for an ordinary insulator (A)

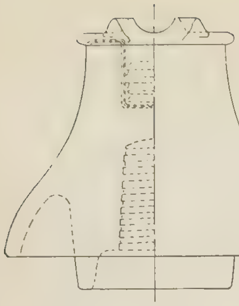
Fig. 4 (left). A new interference proof insulator now available commercially

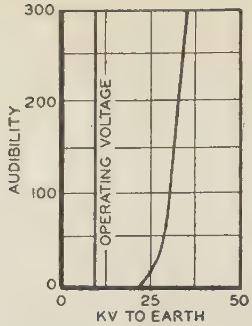
Laboratory tests have indicated that this design is effective in eliminating the "frying" that comes from ordinary transmission insulators. These units thus will make possible satisfactory radio reception for receivers located near transmission lines that formerly were unable to receive satisfactorily because of improperly designed insulators.

Test Method

Before discussing the results obtained, it might be well to describe briefly the method of conducting the tests. In testing insulators or any electric device for radio interference, care must be taken to make sure that the interference comes only from the device under test.

The tests discussed in this article were made with a Radiola model 28 receiving set equipped with special power pack and power amplifiers in the audio stages. To prevent broadcast programs from interfering with tests and to nullify the effects of outside broadcasting to a minimum, an aluminum shield





Figs. 6 (left) and 7 (right). A 20-kv interference proof insulator, and its audibility curve

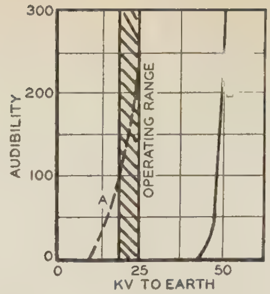


Fig. 8. Audibility curve for a 44-kv interference proof insulator (B) compared to that for an ordinary insulator (A)

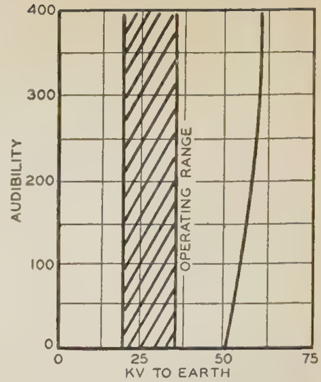


Fig. 9. Audibility curve for a 55-kv interference proof insulator

inclosed the loop antenna. Inside of this shield and insulated from it, was a single turn of wire connected to the pin of the insulator under test and to the ground, so that disturbances set up by corona were carried to the set.

A General Radio Corporation audibility meter was used in the output circuit as a means of determining the effect of increased voltage on audibility. This device consists of shunt resistances and is so designed that the load on the radio set is not changed. Measurements were obtained by raising the voltage until a clear and definite noise was heard in the head set. The voltage then was dropped slowly until the noise was no longer audible; at this point the voltage was read, this voltage being called the radio interference point or voltage.

After the interference point was established, the voltage was raised in 5-kv steps and held at each point while a reading was obtained on the audibility meter. This was obtained by changing the resistance of the meter to the point where the noise died out, the dial reading at that point being called the audibility for that particular voltage. Several such points were obtained for each curve.

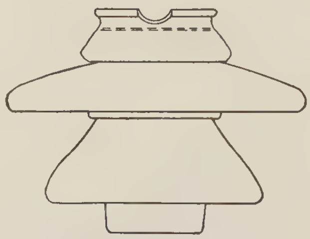
Audibility units obtained were not standard noise units, but represented only an arbitrary value of noise which was used on all tests; consequently these noise units are useful for comparative purposes. The same basis of audibility and noise was used on all tests irrespective of the time elapsed between tests.

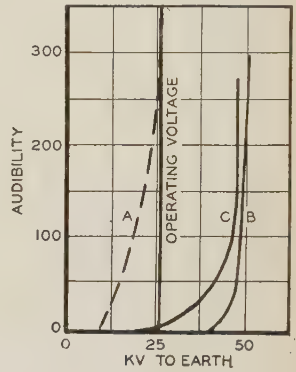
Tests on Interference Proof Insulators

Figure 5 shows the audibility curve for a 66-kv radio-interference-proof pin insulator. The radio interference voltage has been increased from 9.5 to 45 kv to earth. The normal operating voltage to ground is 38.1 kv so that from the standpoint of freedom from radio interference, the factor of safety is 1.2.

A 20-kv rated one piece pin type unit of the same general design is shown in Fig. 6. Figure 7 shows the audibility curve for this new unit. Here again the radio interference point has been increased far above the operating voltage to ground.

In Fig. 8 is shown the audibility curve of a 44-kv unit of the same design with top insert. Since this unit is used on 33- and 44-kv lines, the operating voltages to ground for these 2 voltages are shown.





Figs. 10 (left) and 11 (right). A 45-kv insulator with modified metal cap, and its audibility curve (C) compared with that for an ordinary insulator (A) and for the type shown in Fig. 3 (B)

For the present 44-kv insulator unit the radio interference point is 9 kv to earth, while for the new unit it is 32 kv. Inasmuch as this voltage is used frequently for transmission lines through urban districts it is easy to realize why "transmission fry" prevails on a line which is otherwise in perfect condition.

Figure 9 shows the audibility curve of a 55-kv unit of the same design with top insert. Since this unit is used on 33- to 58-kv lines, the voltage to ground for these 2 voltages is shown. Note that for this unit, which can be used on 33-, 44-, and 58-kv lines (19, 25.5, and 33.5 kv to earth, respectively), radio interference begins at 50 kv to earth. For a 44-kv line the radio interference factor of safety thus is nearly 2 and for a 58-kv line, 1.5.

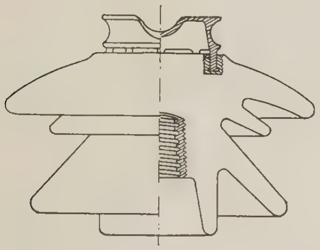
Other Interference Proof Pin Type Designs

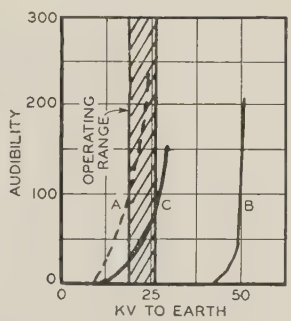
Progress in designing interference free insulators also has been made by other insulator manufacturers. One company shows in its catalog so-called "radio pin type insulators," in the design of which is used a modified form of the metal cap commonly used for bus supports. This design modified the top so that a groove is provided for the line conductor and another groove on the side of the top for the tie wire. A 45-kv insulator unit of this type is shown in Fig. 10.

This modified cap is no doubt a step forward in producing a better radio interference proof design. The performance of this insulator is compared in Fig. 11 with the performance of the unit shown in Fig. 5. The curve shows that the insert design has better non-interference characteristics. However, the modified cap design just described is much better in performance than the present common unit.

Another insulator manufacturer also has developed a radio interference free unit. This third company has used a metal spider cap which has a groove for the line conductor and for the tie wire. In Fig. 12 is shown the general design of this one piece porcelain unit which is rated at 45 kv. Later developments in this unit provided a heavy tar compound in the open spaces between the metal cap and the porcelain body. The life of this compound at the top on an insulator exposed to the elements and possibly to occasional flashovers is questionable. This design, however, is a step forward toward the elimination of radio interference from pin insulators.

In tests on a unit without the void spaces being filled with tar compound, active corona appeared at 17 kv to earth on the top surface of the porcelain around the tines that are inserted into the top porcelain. Active radio interference began at 13 kv to earth. Figure 13 shows the performance curve of this unit as well as a comparison of this unit with a common pin insulator and with the type shown in Fig. 3. This 45-kv insulator unit can be purchased at a cost slightly greater than a common insulator of the same rating, if large enough quantities are ordered.





Figs. 12 (left) and 13 (right). An insulator with a spider metal cap, and the audibility curve (C) for a 45-kv insulator of this type compared with that for ordinary insulator (A) and for the type shown in Fig. 3 (B)

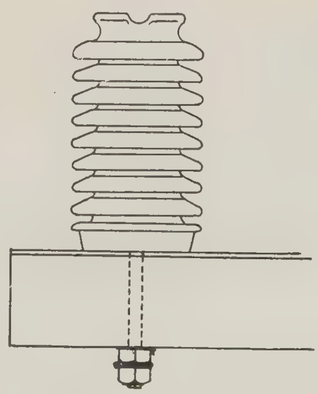
Another insulator manufacturer has digressed from the usual pin insulator design by converting a fog type insulator unit into a so-called "non-static" line post insulator. The base of the insulator unit rests directly on the supporting crossarm. The pin hole problem within the common insulator thus has been greatly simplified. However, recent developments indicate that pin and pin hole problems are the least significant. Figure 14 shows the general design features for a 45-kv rating. In Fig. 15 the performance characteristics of this unit are shown; this shows that the new design departure is better than the common pin unit yet the curves show that it is noisy at less than normal operating voltage. For comparison the curve for the unit with the metal insert (Fig. 3) also is shown. Development of this unit is another example indicative of efforts expended to reduce radio interference from transmission lines.

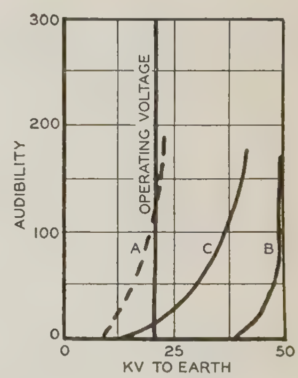
Still another company manufacturers a pyrex insulator with a thin conducting coating over the inner top surface of the unit and in the pin hole. This conducting coating can be seen if the eye follows closely and watches for the faint rainbow colors. A megger test on this treated surface indicates conducting characteristics even though the glass looks transparent. Laboratory tests proved that these units were very quiet on overvoltage stresses. There is no doubt that the placing on the market of this coated unit inspired in a competitive way the porcelain manufacturers to produce a product equally as quiet.

No curve is shown for the performance of this type of insulator; no units are illustrated or described in this article. The short life of any thin coating and the possibility of a flashover destroying or injuring the coating, thereby leaving an insulator less quiet than a common insulator unit, has eliminated further mention herein.

Another feature not to be overlooked with the use of treated insulators is the necessity of like or closely alike metals in contact with the treated section of the insulator. Action has been known to result between the conductor and the insulator such that it was necessary to change the insulator.

Another insulator manufacturer has developed a porcelain adapter that can be added to existing pin insulators; an improvement is claimed where such an addition is made to the present unit. This adapter is designed to fit over the insulator pin; the bottom rests directly on the crossarm, the sides are corrugated, and the top is beveled to be approximately parallel with the inside surface of the lower porcelain skirt. The top does not touch the porcelain of the regular insulator. There is actually a gap between the two different porcelain units. Different sized adapters are made for the different





Figs. 14 (left) and 15 (right). A "non-static" fog type insulator and the audibility curve (C) of a 45-kv unit of this type compared with that of an ordinary insulator (A) and of the type shown in Fig. 3 (B)

insulators and pin shapes. The design consequently permits the use of present standard equipment.

Pin Insulators Compared With Suspension Units

Much has been said about the merits of bell type units so far as radio interference is concerned. A laboratory test was conducted with 5 $10 \times 5^3/_4$-in. ball and socket units with a standard 9-in. suspension clamp (5 bell units in suspension is common practice for a 66-kv line). The voltage to earth for such a line is 38 kv. Figure 16 shows that no interference develops until the voltage is 60 kv to earth. This gives a radio factor of safety of about 1.6. Note the comparison between 5 bell units as against the best performing insert type radio interference proof insulator for the same voltage; the new pin unit closely approaches the present performance of bell type construction.

As a matter of further interest a test was conducted with a 20-in. round grading shield on the bell string. A decided improvement is evident, for with this combination interference starts at about 80 kv to earth.

Equipment for Existing Insulators

Grading rings and shields have proved to reduce radio interference from pin type insulators; for example, a common tin can inverted over the tie head of an ordinary pin insulator has improved the non-radio-interfering characteristics of one size of insulator unit 35 per cent. Figure 17 shows a shield designed for a small unit; such shields cost about $0.25 each. Tie wires can be used to hold the line conductor in place and therefore the shield can readily be added to existing lines. The shield distributes the electric stresses around the tie wires and the line conductor, thereby raising the interference voltage above that of the bare insulator alone. Therefore, the shield is capable of dampening corona that otherwise would appear more easily on the insulator top and tie wire grooves. Such devices can be called corona shields; no ordinary power flashover will injure them seriously, and accordingly they should last indefinitely. For aluminum lines no doubt an aluminum cap would be the most desirable. Experience may prove that these shields have merits for existing lines.

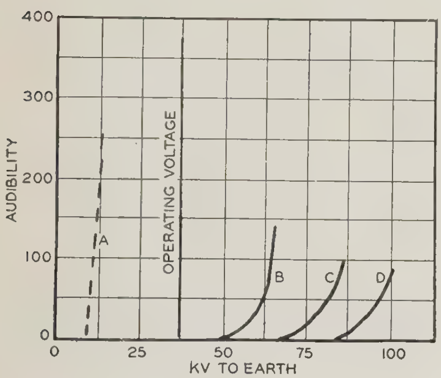


Fig. 16. Comparison of audibility curves for 66-kv pin insulators and a string of 5 $10 \times 5^3/_4$-in. "bell" type suspension units

A. Ordinary pin insulator
B. New insert type (Fig. 3)
C. 5 "bell" units
D. 5 "bell" units with grading ring

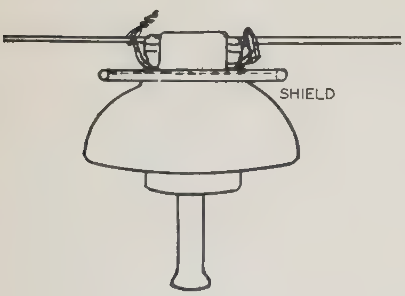


Fig. 17. A shield designed to reduce interference from existing insulators

Grading rings also have been tried out in the laboratory with an improvement as a result. There is, however, only about one size that works to the best advantage for each insulator. Tests have shown that too small a grading ring is not effective; too large a ring causes too much capacity effect. One insulator, for instance, was improved 28 per cent with a grading ring. Figure 18 shows a typical ring installed. Such a device can be held by the conductor and the existing insulator, and the tie need not be disturbed when the ring is added. The ring divides the stresses around the tie wires and line conductors, thereby increasing the voltage at which breakdown and brush discharge occurs. The actual merits of such a device for reducing interference on existing lines is yet problematical.

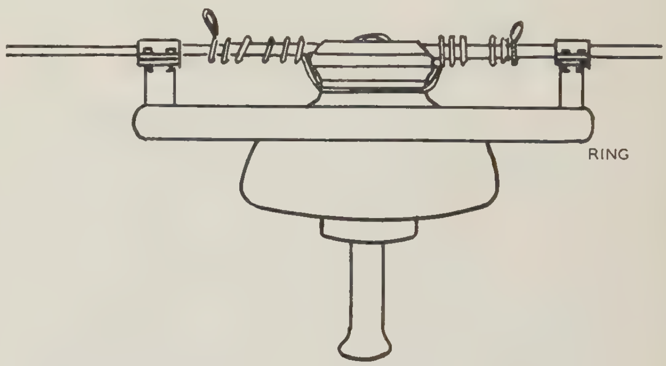


Fig. 18. A grading ring installed to reduce interference from an existing insulator

Experiments have been conducted, but as yet no recommendation as to the actual field performance is available. Existing financial conditions have retarded much of the development and field trials that otherwise would have been carried out.

Metallic Paints and Copper Braids

The use of any metallic paint around the head of the insulator is considered inadvisable. There is no doubt that some relief is obtained temporarily by the use of such special paint; however, the destroying influences of the elements and of electric power arcs make such practice hardly more than a makeshift solution. Metallic paints may have some use for hardware bonding and for pin holes. It has been applied on the cob of the pin at the time the insulator was screwed on, with rather satisfactory results. However, the use of an insulator with a zinc thimble

on a good threaded pin seems to eliminate any necessity for painting the pin hole. There are only a few conducting paints that have any value, and care should be used in making a selection.

The use of copper braid around the tie wire groove of insulators is not satisfactory. The slight improvement temporarily gained is not commensurate with the expense in making such installations.

Executives are not satisfied to make expenditures unless a decided improvement will result. With all the complexities involved in the elimination of radio interference, there is only one recourse that should be resorted to and that is to make only those changes that are sure to lower materially and permanently the noise level of the line involved. Furthermore, it should be remembered that the corona and brush discharges on the insulators may not be the only factors requiring corrective measures.

Conclusions

The construction of any transmission line with the old pin type insulators appears to be only perpetuating trouble. It may be profitable to consider all new purchases of pin type insulators of the non-interference type, even if they are to be used only for replacements. Instead of purchasing quantities of the old style units for stock, new insulators of the non-interference type could be installed in urban districts where transmission noises now prevail and the removed units could be put in stock for emergency replacements in outlying non-urban districts.

As further progress is made, undoubtedly a non-interference type of all-porcelain unit will be developed. This will be free of any metal cap by the substitution of a conducting porcelain head. A high resistance clay porcelain insert may be developed with characteristics like "zircon" or "thyrite," that will result in an even better unit at a lower manufacturing cost.

Actual field performances with interference proof pin insulators have been too few to warrant any comments now. Yet if the field observations of the better designed units prove as satisfactory as the laboratory results indicate, then the field results should be most gratifying. [Ed. Note: Since this article was prepared, 100 interference-proof insulator units have been installed in a midwestern municipality; they have been found to reduce the interference materially. An additional quantity of the new units has been ordered to replace all old style units within the village limits.]

Engineers must fully recognize that radio noises are caused from innumerable sources. The installation of non-interference pin insulators obviously will eliminate only one of the potential sources of interference.

Inasmuch as radio is the most overwhelming agency in the history of communication, any corrective measures to improve this agency assists, as George Wolters of California says, to "throw open a theater whose pit is the seven seas and whose roof is the Heaviside layer. . . . It has brought happiness to rich and poor alike. It knows no creed, no color, no international boundary lines."

Simplified Control for A-C Locomotives

In a control system recently developed for single phase electric locomotives using commutator type motors, the entire heavy and bulky switchgear is replaced by a simple high voltage tap-changer. This article gives the operating characteristics for a device of this sort, and points out its advantages over the unit switch control system and over low voltage control systems in general.

By
W. A. GIGER
ASSOCIATE A.I.E.E.

Allis-Chalmers Mfg. Co.,
Milwaukee, Wis.

SPEED CONTROL for single-phase electric locomotives with commutator type motors is accomplished by supplying the motor with selectively predetermined voltages. Most control systems in common use today obtain the desired voltage variations from suitable taps on the low voltage side of the locomotive transformer. It is extremely important that the power flow to the motors not be interrupted during the transition from one transformer tap to the next. Such interruptions of power flow are destructive to the motors, the gearing, and to the mechanical parts of the locomotive as a whole.

Several methods have been devised to accomplish the transition between transformer taps without interrupting the power flow to the motors. A typical arrangement in common use in the United States is shown in Fig. 1. Switches 1 to 8 must be closed in a certain sequence to prevent short circuits between transformer taps of different potentials. The preventive coil *D* is provided to insure a transfer from one tap to the next without interrupting the power flow to the traction motors. It also permits 2 switches of different potentials to be closed at the same time without producing an unduly high short circuit current in the transformer section between those switches. Other similar arrangements have been devised, some of which utilize more than one preventive coil.

Most control systems, however, using preventive coils have highly undesirable features. The sudden changes in the magnetic conditions of the preventive coil during switching operations are a source of voltage surges which can be detrimental to the

Based upon "Simplified Speed Control for Single-Phase Locomotives" (No. 33-11) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23-27, 1933.

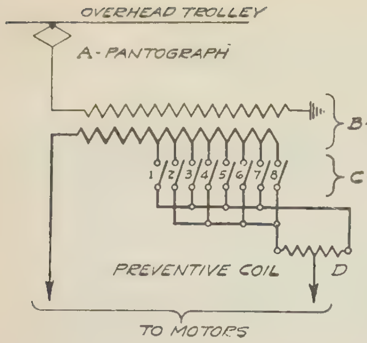


Fig. 1. Schematic diagram of main power circuit of a locomotive using a unit switch control system

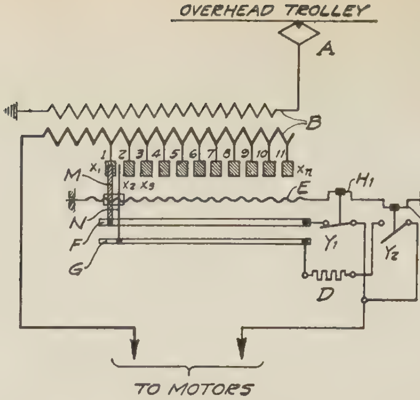


Fig. 2. Diagram of main power circuit of a locomotive using a low voltage tapping switch with bridging resistance

apparatus connected to it. In addition, the variations in motor current are sufficiently high to cause undesirable fluctuations in the torque of the motor. These fluctuations can have a decidedly bad influence during the starting period of the locomotive when the accelerating forces closely approach the adhesive limits of the locomotive.

It is possible to reduce the voltage surges during the transition period by connecting a resistance across the preventive coil. In order to minimize the losses in this resistance, however, it is advisable to provide a switch to be closed only during the transition period.

For many years efforts have been made to eliminate the foregoing undesirable effects and to produce a control system which would impart to the locomotive a smooth acceleration. A greatly improved acceleration can be obtained when the transition from one transformer tap to the next is accomplished with the aid of a bridging resistance. This method of control can be applied to either the high or low voltage side of the locomotive transformer.

Low Voltage Tapping Switch Control

A low voltage control system utilizing a bridging resistance is illustrated in principle in Fig. 2. This system is used to a great extent in Europe where more than 350 electric locomotives and motor cars are equipped with it. In this system the number of taps on the transformer is equal to the number of running steps of the locomotive. Each transformer tap is connected to a block contact $X_1 - X_n$ of the tap-changing apparatus. Two brushes M and N (one main and one auxiliary brush) are arranged in such a way that they can be moved along the block contacts by means of a screw E. Main brush M is constantly in contact with busbar F, whereas auxiliary brush N is always connected to busbar G. Operating screw E is usually motor driven, but manual operation is also easily possible. Busbar F connects with switch Y_1; busbar G through the damping resistance D connects with switch Y_2.

Assuming that brush M is on block contact X_1 (running position 1, for instance) when switch Y_1 on account of its connection with crank shaft H_1 is closed, current flows directly to the motors. Auxiliary brush N is now between block contacts X_1 and X_2, so that no current can flow through it. Furthermore, switch Y_2 being connected to crank H_2, which is opposedly located to H_1, is open. To make the transition from tap 1 to tap 2, the screw is rotated

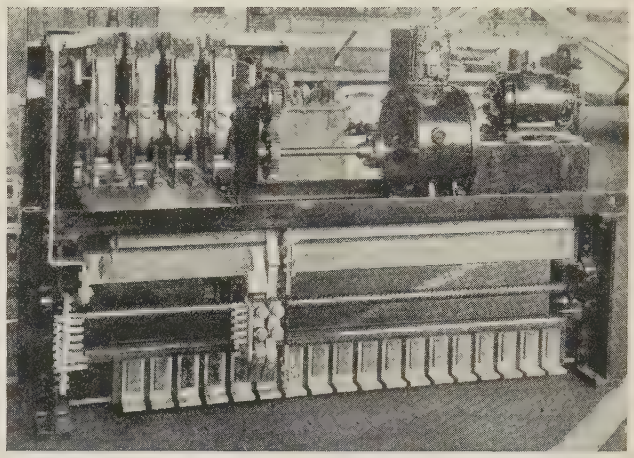


Fig. 3. Tapping switch with 4 arcing switches for use with 2 1,250-hp single phase motors

in such a direction that both brushes M and N move toward block contact X_2; auxiliary brush N reaches block X_2, before switch Y_2 is closed; switch Y_2 now closes so that the motor current flows over the 2 arcing switches Y_1 and Y_2. A short circuit between the 2 transformer taps 1 and 2, is prevented by resistance D, which is in the circuit of the auxiliary switch Y_2. Before main brush M leaves block contact X_1, however, switch Y_1 breaks that circuit and the current flows now only through auxiliary brush N, busbar G, resistance D, and switch Y_2 (which is now closed) to the motor. An instant later, main brush M leaves contact X_1. Both brushes move on until main brush M has made contact with block X_2. Now arcing switch Y_1 closes again and both brushes carry the motor current; an instant later, arcing switch Y_2 is opened so that no current is broken when auxiliary brush N leaves block X_2. The same cycle is repeated whenever a change to another transformer tap is performed.

With the arrangement shown in Fig. 2, it is possible, therefore, to accomplish tap changing under load, without any current interruptions, all arcing being done by arcing switches Y_1 and Y_2. The number of such arcing switches naturally depends on the current capacity and number of the main motors, but is much less than for the unit switch control system. For quick power interruption at any operating step, the insertion of an electrically or pneu-

matically operated switch into each motor circuit is recommended.

Advantages of this control system are numerous. From an operating standpoint, a locomotive equipped with such a system has been found to operate exceedingly smooth; because of the absence of undesirable current variations during the transition periods, and particularly during the period of acceleration, no jerking or shocks of any kind can be felt. The result is that in locomotives with this type of control the wheels have considerably less tendency to slip. Furthermore, the equipment for this system is lighter and requires less space than that of a contactor control system, and the maintenance cost is lower. An additional advantage is that the tapping switch can be built as a unit with the locomotive transformer in such a way that very short copper connections between transformer and control apparatus are required.

That the transition of control steps of a locomotive with tapping switch control usually are exceptionally smooth, is shown clearly in Fig. 4. Both diagrams were recorded by the indicator of a dynamometer car on the same day and with the same 520-ton train. Upon comparing the 2 characteristics, it may be noted that the tractive effort variations during each transition for locomotive *B*, reach approximately 15,500 lb; for locomotive *A*, they amount to only about 5,000 lb. Locomotive *B* incidentally was accelerated somewhat faster as is indicated by the shorter time that was required to reach a certain train speed. A reduction of the accelerating rate of locomotive *B* will not eliminate the oscillations shown in the diagrams, although they might be reduced somewhat in their magnitude.

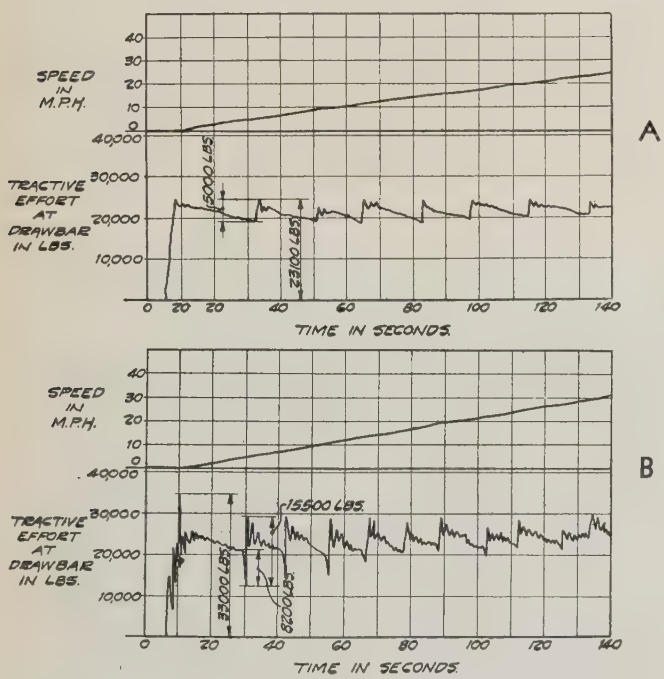


Fig. 4. Starting characteristics of 2 single phase locomotives built for the same service requirements

A. Locomotive equipped with tapping switch control
B. Locomotive equipped with unit switch control and preventive coils

It would be unjust, however, to ascribe the characteristics of the locomotives entirely to the electrical control system used. It is not only the control system that is responsible for what is being measured at the drawbar, but also the kind of mechanical transmission interposed between the driving motor and locomotive wheels, and the kind of spring arrangement of the couplers. In the foregoing comparisons, each motor of locomotive *A* was equipped with a flexible pinion, a solid gear, and a Brown Boveri individual axle drive (Buchli gear). The only flexible member in this entire drive system is the spring pinion as the type of axle drive used does not permit any angular displacement between the driving and driven parts. Locomotive *B* was equipped with solid pinions and gears, but for the flexible medium between gear and driving wheel, a spring quill drive was used. The flexibility of this quill drive is considerably greater than that of the flexible pinion of locomotive *A*, with the result that certain motor torque variations created by the control system are magnified on account of possible angular oscillations of the motor armatures.

The preceding discussion does not particularly mention the ways in which the various switches in each system are controlled. There are numerous ways to accomplish this. Most unit switch control systems use either electropneumatically or electromagnetically operated switches. Other systems utilize a cam shaft, which when rotating, closes the switches in a predetermined sequence. In the arrangement shown in Fig. 2, no special interlocks are necessary, as the crank shaft and the screw automatically synchronize the arcing switches and the moving brush contacts.

High Voltage Tapping Switch Control

A new control system, which disposes of all the complicated and heavy low voltage apparatus of single phase locomotives, recently has been developed. It has been put into successful operation on some large locomotives on the Swiss Federal Railways. With this system, the motors with their reversers are connected directly to the low voltage terminals of the transformer. This is accom-

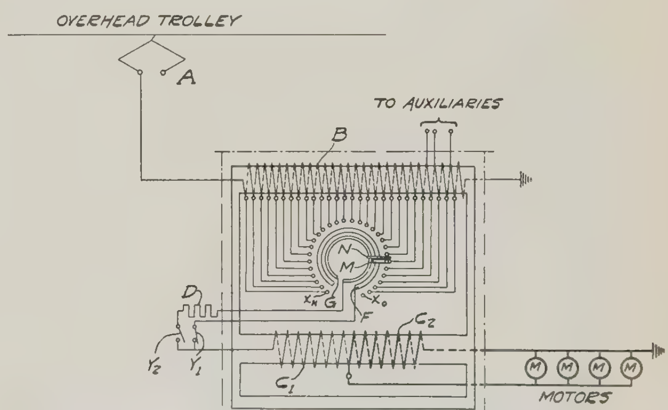


Fig. 5. Main power circuit of a single phase locomotive with high voltage tapping switch and bridging resistance

plished by shifting the voltage regulation to the high voltage side of the transformer, as shown in Fig. 5.

Current at high voltage collected from the overhead wire flows into the high voltage transformer coil B; this coil is equipped with a certain number of taps $X_o - X_n$. When starting the locomotive, the tap changing elements gradually move from tap X_o toward tap X_n. At this last tap coils $C_1 - C_2$ obtain full potential, and, therefore, also the motors which are connected to winding C_2. Switching from one tap to the other one is accomplished in the same manner as with the low voltage tap-changer shown in Fig. 2. The same smooth operating characteristics, therefore, are obtained as with locomotive A of Fig. 4. The principal difference, in addition to extreme simplicity, is that the high voltage tap-changer carries comparatively small currents. A single phase locomotive for operation on 11,000 volts, 25 cycles, having 4 625-hp motors, 2 of which are permanently connected in series and the 2 groups in parallel, draws approximately 6,500 to 7,000 amp during the start; this current must be carried by all apparatus in that circuit. If the same locomotive were equipped with high voltage control, the starting current would be only approximately 350 amp.

Since the high voltage tap-changer has to handle any voltage up to full overhead line potential, but since it never breaks the current, it is logical to build it as a unit with the main transformer and to submerge it in oil in order to obtain better insulation. This arrangement gives small dimensions; furthermore, the oil insulation provides excellent lubrication and good cooling of the apparatus. It is possible also, of course, to connect the high voltage tap-changer to an air-blast transformer. In that case the advantage of an unusually large saving of space obtained with the oil transformer and tap-changer unit will be greatly minimized because the leads connecting the high voltage transformer winding with the tap-changer, as well as taps within this apparatus itself, must be spaced considerably wider.

A locomotive equipped with high voltage control is shown with side walls removed in Fig. 6. The oil transformer built as a unit with the high voltage controller is mounted in the middle of the locomotive. At the left end of the cab, the oil cooling unit can be seen. The control apparatus located opposite the railway motors is necessary because this particular locomotive is equipped for regenerative braking. The 2 contactors X_1 and Y_2 of Fig. 5, are outside of the transformer tank, arranged in such a way that by means of a cam shaft they are always synchronized with the tap-changing unit so that no current is broken within the oil tank. These 2 switches are the only arcing switches required for the entire main power control range of the locomotive. It is expected that the erection and maintenance cost of a locomotive will be appreciably reduced with this new control system.

Besides simplifying the arrangement and improving the accessibility of the main motors within a locomotive cab, this new control system also permits a reduction in weight of the electrical equipment. This is shown in Table I. No weights are indicated for apparatus that is common for both control systems, but only those that differentiate each locomotive from the other. The locomotive in question is rated at 11,000 volts, 25 cycles, and is equipped with 4 850-hp motors.

Table I—Comparative Weights of Unit Switch Control and High Voltage Tapping Switch Control Equipments

A. Locomotive With Unit Switch Control System	Pounds
Air blast main transformer, 3,500 kva	25,500
3 Preventive coils	4,500
Approximately 22 contactors, including mounting frames	5,000
Blower group for transformer and preventive coils	2,800
Copper connectors between transformer, preventive coils, and switch groups	1,500
Total	39,300
B. Locomotive With High Voltage Control System:	
Oil cooled main transformer, 3,500 kva (including oil)	27,000
High voltage tapping switch, including pilot motor drive	1,300
Oil cooler complete, and oil pump	4,800
Oil in pipes and cooling unit	600
Total	33,700
Saving in weight approximately	5,600

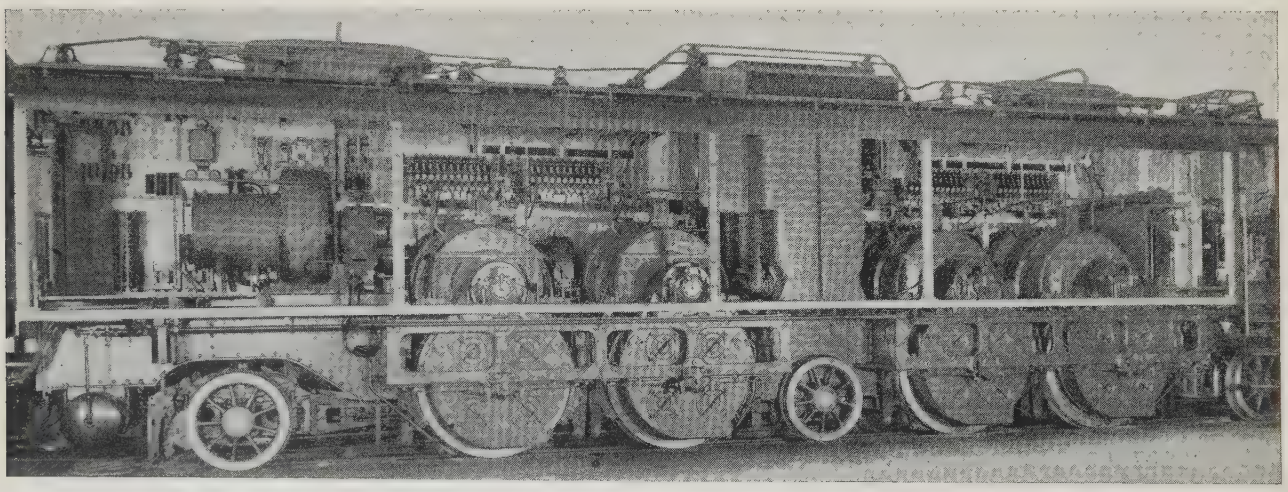


Fig. 6. A locomotive equipped with high voltage tapping switch control, with side walls removed. The compartment housing the tapping switch may be seen on the left side of the transformer

Variable-Voltage Oil Drilling Equipment

Variable-voltage d-c drives have been applied successfully to both the cable tool and rotary methods of oil well drilling. This article gives a comparison of characteristics of 4 different combinations of electrical equipment for this service. Although the method of comparison used is applied only to internal combustion engine d-c electric drives, it may be used advantageously for comparing other types of prime movers.

By
A. H. ALBRECHT
MEMBER A.I.E.E.

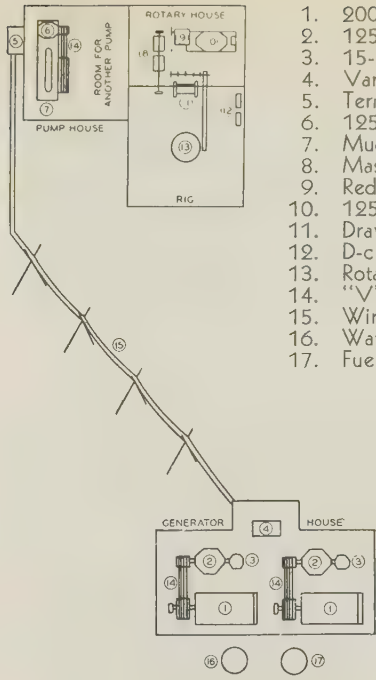
Standard Oil Co. of Calif., La Habra

VARIABLE-VOLTAGE d-c drives represent the most recent advance in electrical equipment for drilling oil wells and have been successfully used in both cable tool and rotary methods of drilling. In cable tool drilling, which consists of merely raising and dropping a heavy bit by means of a walking beam, the characteristics of d-c equipment improve the motion of the drilling tool and reduce the time required for withdrawing the tools from the hole. Rotary drilling, with its greater power requirements and greater complexity of operations, shows a more marked improvement when performed with d-c equipment than does cable tool drilling.

There are 2 fundamental operations in drilling by the rotary method, namely, the drilling and the hoisting operations. The drilling operation is accomplished by the downward pressure and cutting action of a revolving steel bit. The bit is rotated by means of a long steel pipe, extending from the drilling tool upward to a power driven rotary table mounted over the mouth of the well. Although the table has a positive grip on the drill stem, the latter is free to move vertically through the table while it is in motion.

To the top of the drill stem a swivel is attached; this provides a means of suspending the stem in the well allowing it to rotate with the table, while the upper part of the swivel, the hoisting block, and supporting cable, remain stationary. The drill stem and swivel are hollow so that mud can be pumped down the drill pipe to the drilling bit and out into the well through suitable holes in the bit. This fluid picks up the material loosened by the bit and carries it to the surface through the space between the drill pipe and the walls of the well. This circulation of fluid through the well is maintained by 2 pumps connected through a flexible hose to the swivel on top of the drill stem.

Essentially full text of a paper "Variable Voltage Oil Well Drilling Equipment," (No. 33-29) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.



1. 200-hp internal combustion engine
2. 125-kw d-c generator
3. 15-kw d-c exciter
4. Variable-voltage control
5. Terminal box
6. 125-hp d-c mud pump motor
7. Mud pump
8. Master control
9. Reduction gear
10. 125/250-hp d-c drilling motor
11. Drawworks
12. D-c ammeters
13. Rotary table
14. "V" belt drive
15. Wiring carried on "X" supports
16. Water tank for engines
17. Fuel tank for engines

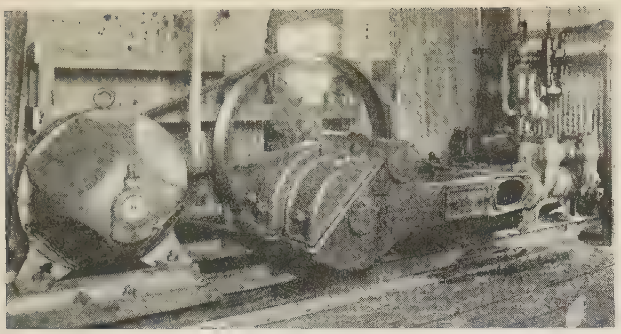
Typical layout of variable-voltage d-c equipment for oil drilling

The swivel, drill stem, and bit may be raised or lowered in the well by means of a steel cable operating through a hoisting block strung from sheaves at the crown of the derrick. The free end of this cable passes down the derrick and is wound on a hoisting drum; this drum is a part of the drawworks which serves as a distribution center for all power driven parts of the rig except the pumps. A system of chains, sprockets, and clutches is so arranged that normally 4 speed rations may be obtained at the drum.

In order to replace a dulled bit, the entire drill stem must be withdrawn from the hole; this is done by removing the drill pipe in approximately 90-ft sections. During this operation, the hoist motor is loaded to its maximum capacity, for it is customary to hoist the drill stem at the greatest practical speed. When returning the drill stem into the well, it is necessary to raise the empty elevators as rapidly as is practicable.

For performing the complete hoisting cycle in the most satisfactory manner, it is necessary that the hoisting motor be capable of exerting high torque for short periods of time, have a high no-load speed, and be capable of being reversed quickly.

Pumps used for circulating the mud are required to operate over a wide range of pressure and volume. Should the bit become plugged, it is desirable that the pumps stall at a safe working pressure. To perform all of its operations satisfactorily, the mud pump motor must have a high no-load speed and a definite limit of maximum torque; and, because of the continuity of its operation, it should operate efficiently at all speeds.



View of electrically driven mud pump

A typical installation of a variable-voltage drilling equipment consists of a power plant located at a safe distance from the drilling rig, and 2 motors located in the drilling rig. The power plant consists of 2 d-c generators with direct connected exciters. These generators may be driven by an a-c electric motor taking energy from the usual power supply, or by steam or internal combustion engines. In all of the installations made to date internal combustion engines have been used. Requirements for the prime movers are that they have sufficient horsepower capacity, good speed regulation, and lower operating costs.

Of the 2 motors installed in the drilling rig, one drives the drawworks and is used for either drilling or hoisting, and the other drives the mud pump. During the drilling operation, one generating unit supplies power to the drilling motor and the other to the mud pump motor. During the hoisting operation, however, as the mud pump ordinarily is not used, both generators supply power to the drilling motor.

Four Motor and Generator Combinations Studied

In view of the different operating characteristics obtainable by the use of various types of motor and generator windings and interconnections between machines, an investigation was made to determine which combination was best suited to rotary drilling. This study included the following combinations:

1. Differential generators designed for series connection, supplying energy to a shunt drilling motor.
2. Differential generators designed for parallel connection, supplying energy to a shunt drilling motor.
3. Differential generators designed for series connection, supplying energy to a compound drilling motor.
4. Shunt generators designed for series connection, supplying energy to a compound drilling motor.

Variable-voltage control is used with each combination. In combinations 1, 3, and 4, the 2 generators are connected in series for the hoisting operation. With such a connection the drilling motor is operated at double voltage, thereby doubling the motor speed and output; however, neither the motor current nor available motor torque is changed. In combination 2, the generators are connected in parallel for the hoisting operation. With that connection the voltage applied to the drilling motor remains the same as when one generator is connected to it, but the available current is approximately doubled, thereby doubling the output of the drilling motor.

In order to make a complete study of the series and parallel connections under discussion, the following points are considered:

1. Suitability of operation.
2. Relative costs.
3. Relative safety.
4. Choice of size of equipment.
5. Choice of electrical characteristics.

Since this is a comparison of electrical equipment and schemes of arranging electrical equipment, the drawworks efficiencies are considered to be 100 per cent. The excitation is considered constant in all combinations.

Suitability of Operation

For parallel operation it is necessary to use differential compound generators. These generators have 2 fields; a separately excited shunt field, and a differential self-excited field. The differential series field opposes the shunt field, thereby causing the generator voltage and consequent motor speed to droop with an increase of load. This characteristic permits adjustment of the generator output to a value such that the prime mover cannot be stalled during normal engine operation, consequently preventing the overloading of the prime mover.

Assume, for example, that 2 differential generators are being operated in parallel, driven by separate engines. If, for any reason one engine slows down, the voltage of its generator drops causing a partial transfer of load to the other generator. This transfer is momentary and when stability is reached, the resultant voltage and output of the slower generator is reduced slightly. The division of load on the generators is in proportion to the respective engine output. Any difference in engine speeds causes an unequal division of load current between the generators, the machine running at the higher speed supplying the larger part of the current.

View of derrick floor showing rotary table with upper end of drill stem, and front of drawworks at the right

Successful operation of duplicate d-c generators in series is attained with either shunt-wound or differentially compound-wound generators. If duplicate d-c generators are being operated in series and the speed of one engine decreases, the output of its generator decreases in proportion. As the current output is not affected, the available motor torque remains unchanged, but the motor speed is reduced in proportion to the decrease of terminal voltage. Regardless of the condition of operation, there is, of course, no transfer of load current between generators. However, both machines can become equally overloaded.

Relative Costs

The first cost of the series connected and the parallel connected combination should be practically the same. Experience has shown that if the equipments are properly designed for their operating voltages there will be no appreciable difference in operating cost.

The only difference in the installation costs of any of the 4 combinations is in the wiring. Because the current is doubled when hoisting with parallel connected equipment, the wire to the drilling motor must be approximately double the size used for series connected equipment, for the same voltage drop.

Relative Safety

From a safety standpoint, there is very little advantage to be gained by the choice of either parallel or series connected equipment. In both, the combined no-load voltage of either the hoisting or drilling connection is less than 600 volts. As rubber covered wire used in these installations is rated at 600 volts with a safety factor of 5, and as all live parts normally are protected, both connections are equally safe. In case of trouble the plant operator and not the drilling crew makes the necessary repairs.

Choice of Size of Equipment

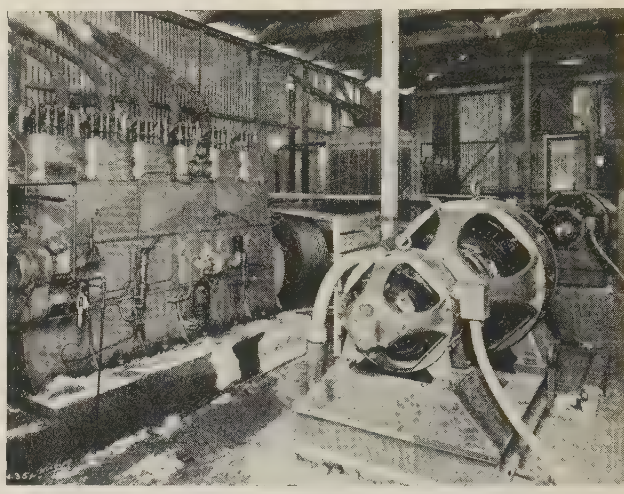
In the comparison made here a power plant equipment consisting of 2 200-hp engines driving 125-kw generators is chosen, this capacity being considered sufficient for present-day drilling. The drilling motor, taking power from both generating units when hoisting, should be designed to have a maximum output of 281 hp; this value represents the combined engine ratings less losses and auxiliary power. It is essential that the characteristics of the drilling motor and the generators be such that the prime mover will operate at its maximum output over the widest possible range of torque and speed.

Horsepower ratings of electrical equipment are the same for all of the combinations being considered; the electrical characteristics, however, are widely different.

Choice of Electrical Characteristics

One of the most important duties of any type or kind of equipment used for drilling oil wells is to hoist strings of drill pipe. Therefore it is reasonable to assume that the best combination of generator and motor characteristics for such work is that in which the engines driving the generators will be loaded to their normal capacity for the maximum time of the hoisting cycle.

In order to make a true comparison of the characteristics of these various equipments and eliminate differences in types and ratings, their speed-torque characteristics are converted into fast-line speed and fast-line pull (the fast line being the one wound directly on the hoisting drum) using the most advantageous drawworks sprocket ratios in each case. Plotting these values in the form of curves, together with a curve representing the net available constant engine output, results in a visual picture of the behavior of each equipment.



Interior view of generating house

In order to convert these values into fast-line speed and pull, it was necessary to assume average values for weights and dimensions of various rig parts, as follows:

1. Average diameter of hoist drum, 30 in.
2. Maximum drill stem to be hoisted, 7,500 ft of 6-in. drill pipe with 8 lines, weighing 235,000 lb, or 29,375 lb on the fast line. This includes the weight of blocks, line, elevators, etc.
3. Maximum fast-line speed, 2,500 ft per min.

The following procedure was followed in calculating the values for the curves:

1. A set of drawworks sprocket ratios is chosen by trial, which gives the best balance of fast-line pulls and speeds.
2. For each drum speed or gear ratio, various available fast-line speeds are assumed and converted into motor speeds.
3. The motor speeds are used to obtain corresponding motor torques. These are taken from speed-torque curves of the motors operating on the voltage of the generator used in the combination of equipment considered in each particular case.
4. The pull, in pounds, for each fast-line speed is calculated.
5. The fast-line velocity-pull curves then are plotted, using the fast-line speed in 2 as ordinates and the pounds pull in 4 as abscissas.

The fast-line velocity-pull characteristics were calculated for each of the 4 combinations and the results plotted in the accompanying curves.

Speed-torque characteristics of combinations 2 and 3 were obtained from electrical manufacturers. Curves for the other 3 combinations were recalculated from manufacturers' curves of different ratings. These estimates are very close, however, and do not appreciably affect the accuracy of the results.

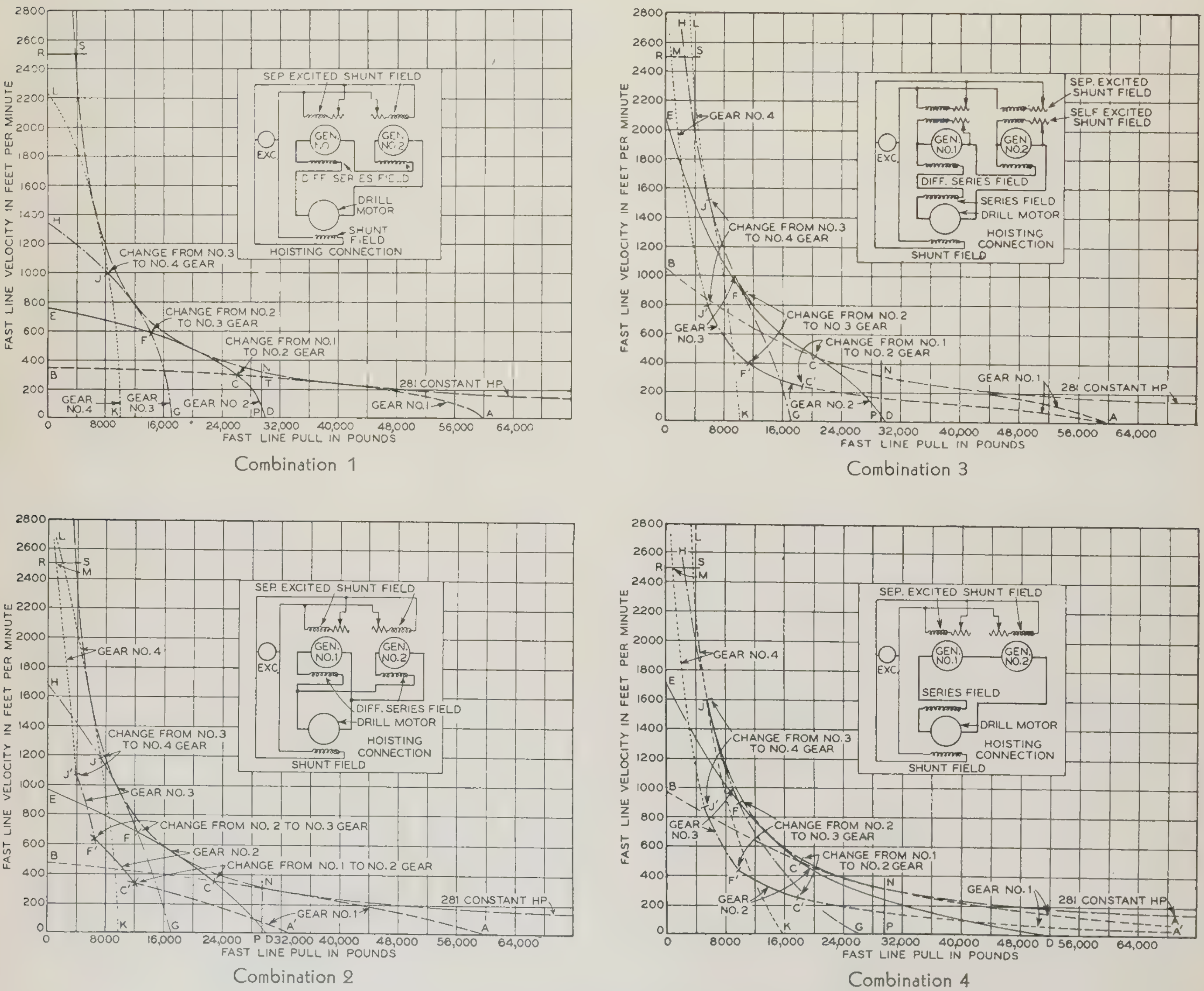
For each of the 4 combinations a constant horsepower curve *NS* (see curves) representing the net available prime mover output of 281 hp first was drawn. This curve represents the characteristics of an ideal equipment having an infinite number of gear ratios and the area under the curve is proportional to the maximum energy expended with this constant output. The velocity-pull characteristics of a 4-speed drawworks then were drawn, using gear ratios which utilize the motor characteristics of each combination to the best advantage. In each case, the characteristics of low-low or No. 1 gear is shown by curve *AB*, high-low or No. 2 gear by curve *DE*, low-high or No. 3 gear by curve *GH* and high-high or No. 4 gear by curve *KL*.

Areas representing the energy expended by equipments driving 4-speed drawworks do not coincide at all points with the ideal area *NPORS*, the motor characteristics determining how closely it is approached. To obtain maximum energy from any combination, it is necessary to change gears at definite values of fast-line pull as shown by points *C*, *F*, and *J* on the curves. The energy obtainable from any of the combinations is proportional to the area *NPORSJFC* and, compared with the area under the ideal curve *NS*, is as follows for the various combinations:

Combination	1	2	3	4
Per cent of area *NPORS*	91.3	96.1	99.7	99.4

On the basis of this comparison, combinations 3 and 4 utilize the engine output to the best advantage.

Under ordinary conditions, it is rather difficult for the driller to know when to change gears; and unless they are shifted at the correct values of pull, hoisting time is lost. This is especially true of combinations 1 and 2 which have the flattest characteristics and hence show the smallest increase in speed with de-



Characteristic curves for the 4 different combinations of equipment

crease of load. Combinations 3 and 4, however, have rapidly rising characteristics and, even if the driller does not change gears at the correct pull, he does not lose much speed over a comparatively wide range of pull.

Another point to be considered is the pull that can be exerted by the various combinations when only one generator is used. In the series system, the fast-line pull is approximately the same, whether 1 or 2 generators are used. However, in the parallel system the fast-line pull, when 1 generator is used, is approximately half that available when 2 generators are used. This is shown in the following tabulation:

Maximum Fast-Line Pull in Pounds

Combination	1 Generator	2 Generators
No. 1	59,800	59,800
No. 2	33,000	59,800
No. 3	59,800	59,800
No. 4	76,200	89,500

It is not improbable that one generating unit would be out of service when a full string of drill pipe is in the hole. Should this occur where the parallel system is used, it would be necessary to increase the number of lines in the blocks, whereas with the series system no inconvenience would be caused except a reduction of 50 per cent in the hoisting speed.

Summary and Conclusions

An analysis of this article shows that all 4 combinations discussed can be used satisfactorily. However, the following summary of the relative merits of the various combinations shows that each equipment has its distinct advantages; therefore, an operator should choose that equipment which would give him the best over-all results.

Type of Generator

Differential. The differential generator limits the load on the engine, limits the pull on the drilling line, and also limits the maximum pressure developed by the mud pump.

Shunt. The shunt generator will not sufficiently limit the load on the engine except when used with a specially designed exciter having a drooping voltage characteristic. This type is not entirely suited to mud pump operation because of the high pressures developed before the motor stalls.

Disadvantages of Parallel Generator Connection

1. If one drilling motor is used for both drilling and hoisting it operates at about half of its rated capacity when drilling. If 2 motors are used and one declutched during drilling, this objection is eliminated, but the installation cost is increased slightly and the equipment is more bulky.

2. The cross section of wire for armature circuits from the generators to the drilling motor must be double the size used in the series system.

3. The fast-line pull available is reduced approximately 50 per cent when one generator is out of operation.

Advantages of Series Generator Connection

1. Drilling motor operates at its rated torque for either drilling or hoisting. For hoisting the horsepower capacity is doubled by increased voltage.

2. Size of wire for armature circuits between generators and motors is half that of the parallel connection.

3. The fast-line pull available is approximately the same with 1 generator as with 2.

Type of Motor

Shunt. The shunt-wound motor in itself has the disadvantage of a flat characteristic which gives little speed variation over its operating range. However, this characteristic is caused to droop by the drooping voltage characteristic of the differential generators.

Compound. The compound motor in itself has the advantage of a steep characteristic which gives wide speed variations over its operating range.

Electromagnetic Effects in Stellar Atmospheres

A brief theoretical discussion of some electromagnetic phenomena in the atmospheres of the sun, the stars, and the planets.

By
J. A. ANDERSON

Mt. Wilson Observatory,
Pasadena, Calif.

A PROBLEM underlying much recent theoretical scientific work is the following: "Granted that electric or magnetic fields, singly or combined, exist in the atmospheres of the stars and planets, what effects would be produced which could be observed by astronomers?" It is clear, of course, that direct observation of such fields is hopeless because of the enormous distances of the heavenly bodies from the earth.

Since electromagnetic fields can act effectively only on charged particles, a prerequisite for any observable effect is that the atmospheres must contain charged particles—in other words that the constituent gases must be somewhat ionized. This is certainly true of the stars and probably true also of the planets.

Conduction of Electricity in Gases

The motion of charged particles in electric and magnetic fields was discussed with his characteristic thoroughness by Sir J. J. Thomson (University of Cambridge, England) in his book "Conduction of Electricity Through Gases." The conclusions which are of importance in the present discussion will be summarized briefly.

Written especially for Electrical Engineering, based upon an oral presentation before the A.I.E.E. San Francisco Section, March 24, 1933. *Not published in pamphlet form.*

At moderate or high gas pressure, where the mean free path of the particles is short, a magnetic field produces little or no effect unless it has an unheard of intensity; an electric field produces a drift of the particles in its own direction, the speed of which is proportional to the field strength. In a crossed electric and magnetic field the motion makes a small angle with the direction of the electric field in the plane normal to the magnetic force.

At very low gas pressure, with a long mean free path the state of affairs is very different. A free charged particle moving in a magnetic field will describe a spiral path about the lines of force. This is because the field has no effect on the component of velocity parallel to the lines of force, while a velocity normal to the field is turned into a circular orbit. The direction of the circular motion is opposite for the 2 kinds of charge, and is such that a negative charge moves clockwise to one looking along the lines of force.

The radius of the circle varies directly with the momentum of the particle and inversely with the product of the magnetic intensity and the charge. Thus if an electron and a charged hydrogen atom have the same kinetic energy the radius of the hydrogen orbit will be approximately 42 times that of the electron orbit; and heavier atoms naturally have still larger orbits.

Considering an electric field alone the only effect of a long free path is to increase the average speed of the charged particles for a given field intensity, and thus to increase the conductivity.

In a crossed electric and magnetic field a new and at first sight a very strange phenomenon appears: The conductivity in the direction of the electric field becomes very small, and charged particles move at right angles to both fields. Strangest of all is the fact that the speed with which the particles travel is independent of both their mass and charge, being the same for an electron a charged hydrogen atom—or indeed any other charged atom. This speed may be determined numerically by the ratio of the electric and magnetic field strengths, multiplied by the sine of the angle between them.

Astronomical Phenomena

Astronomical phenomena which called for explanation may be stated briefly. First we have the magnetic and electric fields of the earth. Many attempts have been made to account for these, with little or no success. The electric field is particularly challenging, for the known vertical current would reduce it to zero in much less than a single day were it not continually renewed.

The magnetic field of sunspots is another riddle. So is one feature of the general magnetic field of the sun which Dr. George Ellery Hale (organizer and now honorary director, Mount Wilson Observatory, Pasadena, Calif.), discovered in 1912. It was found that the intensity of this field diminishes from about 50 gauss to less than half in a vertical distance of at most a few hundred kilometers.

Then, there is the anomalous rotation of the sun, of Jupiter, and probably also of Saturn. Perhaps we can add Uranus and Neptune for good measure, but that is speculation. The anomaly can best be described by referring to the sun. That body rotates in a period of 32 days, as shown by observations of its general magnetic field. The same period is approached near the poles, as shown by observations of surface markings and also by the spectroscope. But toward the equator the visible surface rotates faster and faster so that at the equator itself the rotation period is of the order of only 25 days. This "equatorial acceleration," as it is called, follows a rather simple law depending only upon the solar latitude. Now, the visible solar surface undoubtedly is located rather high up in the sun's atmosphere, so the phenomenon can be described by saying that there is a prevailing westerly wind on the sun having a maximum velocity of nearly $^1/_3$ km per second at the equator and diminishing gradually to zero at the poles. The equatorial acceleration of Jupiter is similar though much smaller.

Ionization of Stellar Atmospheres

Temperature of the sun's atmosphere is so high that its gases must be highly ionized due to this cause alone. In planetary atmospheres the temperature is low so that if any ionization exists it must be ascribed to other causes. The existence of the Kennelly-Heaviside layer shows that there is considerable ionization in the upper atmosphere of the earth. It appears that this ionization can be accounted for adequately by the action of sun and starlight and by the recently exploited cosmic rays. Since these agents also act on the other planets, we may safely conclude that in general planetary atmospheres are considerably ionized in their outer regions.

While it does not seem that a satisfactory explanation can be given for all of the problems mentioned, it does seem possible to give a somewhat plausible one for the equatorial acceleration, and for the rapid diminution of the sun's general field with height. Following Ross Gunn (Naval Research Laboratory, Washington, D. C.) we can account for the equatorial acceleration if we assume that large rotating masses have magnetic fields (such as we know exist on the earth and the sun) and if in addition we are bold enough to assume that the earth's electric field is not simply an accident, but that the other planets and the sun each have a similar field.

According to the principles previously stated, if the magnetic field points northward, the electric field downward, and the mean free path of the ions is long, there will be an eastward drift determined by the ratio of the 2 fields. Knowing the strength of the magnetic field, and the speed of the drift, Doctor Gunn calculated that an electric field of 0.013 volt per centimeter will account for the equatorial acceleration observed on the sun.

This explanation gives the correct law of variation with latitude as observed on the sun, but it demands in the earth's upper atmosphere the existence of a west wind of some intensity. There appears to be no evidence either for or against this.

The diminution of the sun's general magnetic field demands that an electric current be flowing from

west to east. Dr. Sydney Chapman (Imperial College at South Kensington, London, Eng.) finds the origin of this current in the combined action of the gravitational and magnetic fields in the region where the free paths are long.

Under these conditions the positive charges will drift eastward, the negative westward, which results in a current to the east as required. Although the drift velocity is low (1 cm per sec about) Doctor Chapman finds that quantitatively the explanation is satisfactory.

An Oscillograph for 10,000 Cycles

The frequency range of the rapid record oscillograph has been extended beyond the natural frequency of the vibrating galvanometer string by the insertion of electrical networks in the circuit to equalize the natural characteristics of the string. An oscillograph using a string equalized to more than 10,000 cycles is described in this article.* —Editors.

IN THE PAST, oscillographs have been employed over a frequency range extending only to a little below the natural frequency of the vibrating element, and efforts to obtain a wider range have been directed toward raising the resonant frequency of the vibrator. Many of the difficulties and restrictions encountered in this effort, however, have been obviated by a new method of attack.

In brief it consists in equalizing the natural characteristics of the string by electrical networks inserted in the circuit. One part of the network equalizes for the fundamental resonance F_0, and another equalizes the range above this frequency. Other factors enter to limit the upper frequency obtainable, but practically flat characteristics are secured up to about $2^1/_2$ times the fundamental frequency of the vibrator. In its present form, shown in Figs. 1 and 2, the oscillograph uses strings stretched to a natural frequency of 4,500 cycles per sec, and equalized to from 10,000 to 12,000 cycles per sec. With this new equipment most of the components of speech and music may be recorded.

A few years ago a recording oscillograph, of the string type, was developed by Bell Telephone Laboratories that would satisfactorily record frequencies over the part of the voice range important in telephone work. It represented a distinct advance over the oscillograph of similar type developed during the war for locating enemy guns by sound ranging and improved subsequently for studying circuit phenomena. This earlier oscillograph (described in *Bell Laboratories Record*, March 1927, p. 225–7) would record frequencies up to 200 cycles per sec and had facilities for developing and fixing the paper record at the rate at which it was exposed, while the improved oscillograph (described in *Electronics*, August 1931, p. 70–1; *Journal S.M.P.E.*, January 1932, p. 39–53; and *Bell Laboratories Record*, August 1930, p. 580–5) increased the frequency range to 3,000 cycles. This improved instrument, christened the rapid record oscillograph, proved greatly superior to other available equipment and has been used extensively. It is this oscillograph, redesigned to employ electrical methods of equalization, that is described in this article.

Electrical Equalization

Before electrical compensation could be applied, a complete study of the string characteristics of the galvanometer was necessary. If a measurement is made of the deflection of the string by an alternating current of constant value but variable frequency, it is found that the sensitivity increases enormously in the region of its fundamental resonance frequency F_0 and that there are subsidiary resonance peaks occurring at approximately $3F_0$, $5F_0$, $7F_0$, and so on. No signs of resonance appear at even multiples of the fundamental frequency. The odd numbered

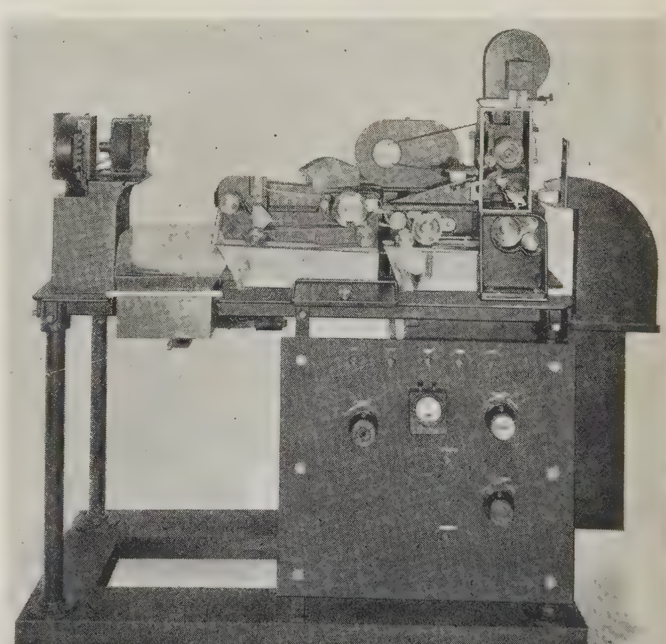


Fig. 1. Front view of the rapid record oscillograph with electrical equalization. The mechanism is shown exposed

* Abstracted from an article "An Oscillograph for 10,000 Cycles," written by A. M. Curtis, Bell Telephone Laboratories, New York, N. Y., and published in the *Bell System Tech. Jl.*, v. 12, 1933, p. 76–90. *Not published in pamphlet form.*

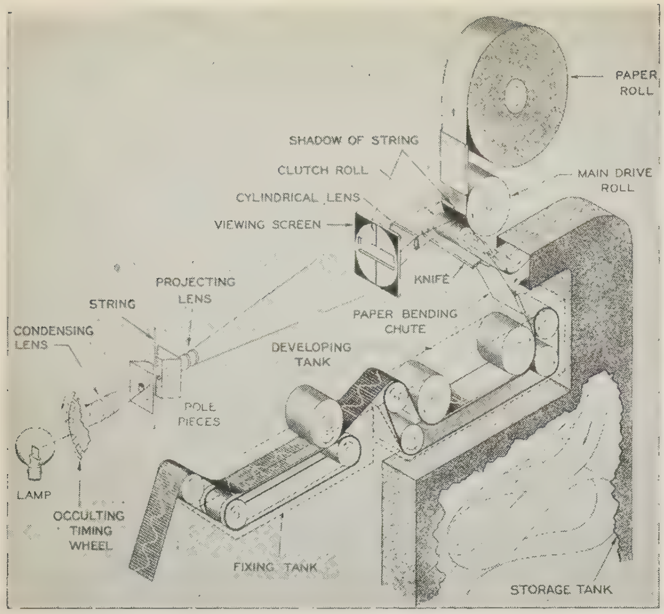


Fig. 2. Diagrammatic arrangement of the new rapid record oscillograph

modes of vibration may not be exact multiples of the fundamental because their frequency is influenced by the beam stiffness of the string. With a relatively short, wide ribbon, for example, the third resonance peak may be considerably higher than $3F_0$. The increase in sensitivity in the neighborhood of the various resonance points is accompanied, as with other electrically driven vibrating systems, by marked variations in the electrical characteristics that the system presents.

If appoximate equalization is desired only to a frequency a little below F_0, and if maximum sensitivity is not essential, it is sufficient to shunt the galvanometer with a suitable resistance. This method of resistance shunt damping, used with the earlier form of the rapid record oscillograph, gives very satisfactory characteristics up to nearly F_0, but it does not develop maximum sensitivity, which for its attainment requires an equalizing network with characteristics inverse to those of the vibrating string. An inductance in series with a capacitance, which resonates it to F_0, and a suitable resistance are sufficient. This type of equalization alone, however, gives a sensitivity at $3F_0$ nearly as great as that at F_0. Because of this there is a greater $3F_0$ distortion with a resonant shunt when a square wave is impressed than with the resistance shunt. The sensitivity at $3F_0$, however, may be damped out by an additional shunt element.

With this arrangement the sensitivity falls off rapidly beyond F_0, but recent advances in the art of designing equalizing networks have made it possible to combine with the string already equalized to its natural frequency of vibration, a second equalizer which extends the range of frequencies through which the deflection is proportional to the current to a point considerably higher than F_0. This is, of course, accomplished at the expense of a corresponding reduction in sensitivity. While a variety of combinations of F_0 and equalizers is possible, a particular case in which a string was tuned to 4,500 cycles per sec and equalized to 10,000 is illustrated in Fig. 3, which shows the circuit of the equalizer and the characteristic obtained.

Arrangement of Oscillograph

The arrangement of the rapid record oscillograph with electrical methods of equalization is shown in the schematic diagram of Fig. 2. Light from the lamp at the left is focused by the condensing lens on the strings of the instrument through the perforated pole piece. Only one of the 2 or 3 strings provided is shown on the diagram. The images of the strings are focused by the projecting lens onto the sensitized paper used for the record, where they appear as shadows on a light background.

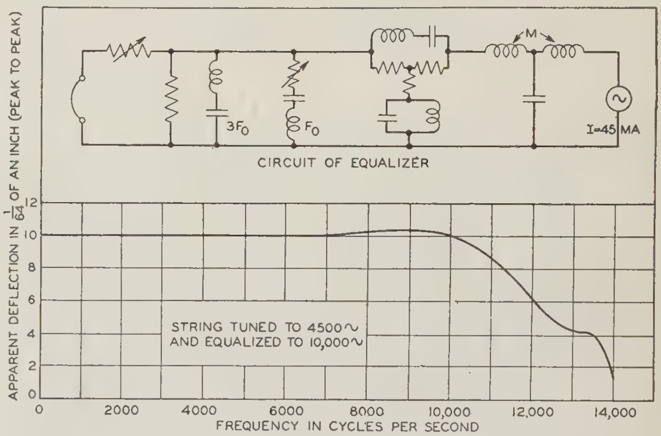


Fig. 3. Equalizing network employed with new oscillograph and the characteristic obtained

An achromatic cylindrical lens in front of the paper further focuses the light into a narrow band with a width of a few thousandths of an inch on which the shadows of the strings fall. As the paper is drawn through the machine, the shadows of the vibrating strings thus photograph on it a trace of the motion of the middle of the string.

Between the lamp and the condensing lens is a timing wheel the rotation of which is controlled by an electrically driven tuning fork. Spokes of the wheel interrupt the light from the lamp every thousandth of a second and thus trace timing lines across the sensitized paper. Every tenth spoke is thicker than the intermediate ones to indicate with a heavier line the hundredths second divisions. Rulings on the cylindrical lens mark horizontal lines a twentieth of an inch apart on the exposed paper to give a convenient measure of the amplitudes of the oscillations.

Two motors operate the exposing, and the developing and fixing mechanisms. One rotates the main drive roll, which pulls the strip of paper from the unexposed roll through the light beam, and pushes it into the developing tank. The second carries the paper through the developing and fixing tanks. Each is adjustable in speed and controlled

separately. The speed of the main drive motor is adjusted to best exhibit the phenomena that are being observed. Maximum speed is about 130 in. per sec, which gives a little over a hundredth of an inch between crests of a 12,000 cycle wave. The motor controlling the developing equipment is adjustable to give paper speeds from 2 to 10 in. per sec. The faster the speed at which the paper is exposed the more slowly will it be developed.

Since the paper being exposed is moving faster than that being developed, a storage reservoir for undeveloped paper is provided as indicated in the illustration. At the beginning of an oscillogram the paper is pushed by the main drive roll in between the drive rolls of the developing tank. Since these carry the paper at a lower speed than the main drive, a loop of paper is formed between the 2 drive rolls and passes into the storage tank. The amount of paper that can be stored depends upon the speed of exposure, and varies inversely with it. At low speed the paper settles compactly in the tank and an entire 250-ft roll may be stored. At high speeds the paper does not have time to settle properly, and only about 55 ft, corresponding to about 5-sec exposure, can be held.

Both motors having been started, operation of the oscillograph is commenced by pulling out a lever which withdraws a knife blade from the paper, and moves an idler pulley, which presses the paper against the main drive roll. The paper is then run through the storage tank and the developing and fixing tanks as already described. After the events under observation have been recorded the starting lever is pushed back, withdrawing the idler pulley from the main drive roll, and releasing the knife, which cuts off the exposed section of paper. An electromagnetic brake, operated by a timing control circuit, is momentarily applied to the spinning roll of paper, and stops it in a fraction of a revolution. The exposed paper continues to pass through the developing and fixing tanks, and into the rinsing tank until it has all been developed. A solenoid may be provided for operating the machine from a distance when desired.

Formulas for Magnetic Hysteresis Losses

By
SURAIN S. SIDHU
ASSOCIATE A.I.E.E.

University o
Pittsburgh, Pa.

This article describes an investigation to determine the magnetic properties of different grades of silicon sheet steel when symmetrically and unsymmetrically magnetized; from the results a formula has been derived which should be of value in designing electrical apparatus used in circuits where alternating and direct currents are superposed.

IT HAS long been known that the Steinmetz formula for magnetic hysteresis loss in iron

$$W_h = KB^c \quad \text{(1a)}$$

or

$$\text{Log } W_h = \log K + c \log B \quad \text{(1b)}$$

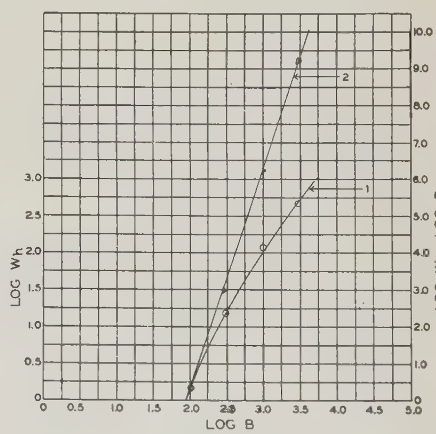
where

W_h = hysteresis loss
K = constant (antilog of γ-intercept of log W_h vs. log B curve)
B = flux density
c = a constant (slope of curve log W_h vs. log B)

does not represent accurately the hysteresis loss beyond ordinary ranges of induction. The exponent c, which is considered constant according to the above relation, has been found to vary not only with different kinds of iron or steel, but also with the induction in a single sample. Methods that have been used universally to determine the value of c have depended on the erroneous assumption that it is always a constant. Hence, a value obtained in that way is usually not correct over an extended range of inductions.

From experiments with hysteresis loops, super-

Fig. 1. Relation between (1) log W_h and log B and (2) log W_h log B and log B of Steinmetz's formula $W_h = KB^c$



Prepared especially for ELECTRICAL ENGINEERING; based upon work done at the research laboratories of the Union Switch and Signal Company, Swissvale, Pa. *Not published in pamphlet form.*

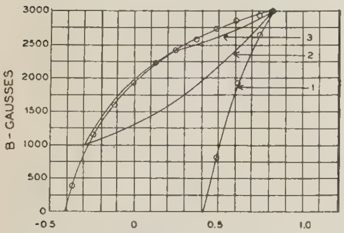
posed on maximum flux densities of 10,000 gausses or more, a curve of the form of curve 1 in Fig. 1 is obtained instead of a straight line. Therefore, both the exponent c and the coefficient K are variable. In a hysteresis loop thus displaced there results not only a change of shape but also a change of area, and the relation between the hysteresis loss and the induction seems to become too complicated to be expressed by Steinmetz's Law or by any other equation based upon straight line relations. By a *displaced* or an *unsymmetrical loop* is meant a hysteresis loop obtained when the magnetism is carried through a cycle in which the limiting values of flux are different in amount, or in other words, the mean value of the flux differs from zero.

Among previous investigators on hysteresis losses due to displaced loops, John D. Ball[3] was the only one who formulated any definite law from his data although each of the others gave several general conclusions. The general equation given by Ball is of the form

$$W_h = (N + aB_m^{y})\, B^{x} \tag{2}$$

where N and x are constants similar to those of the Steinmetz formula; a is a coefficient depending upon the material; y, a power of the mean density B_m; and B, the superposed flux density. The results and analyses of Ball's tests show that N, a, x, and y all vary with induction. Although he expressed the hysteresis loss for a displaced loop as a function of the mean induction, the form of the equation has not been changed materially from that of Steinmetz. Chubb and Spooner[2] also have pointed out that the hysteresis loss in sheet steel does not follow the Steinmetz law when the material is unsymmetrically magnetized, since both the coefficient and the exponent are found to change with displacement.

The purpose of the investigation discussed in this article was (1) to study the magnetic properties of silicon sheet steel of different grades when it is symmetrically and unsymmetrically magnetized, (2) to determine the effect of annealing on hysteresis loops, and (3) to derive an equation that would express the relation between the hysteresis loss and the pulsating induction accurately enough to be useful in the economical design of such apparatus as is used in circuits where alternating and direct currents are superposed.



1. Half of normal loop, 3,000 gausses
2. Loop ± 1,000 gausses superposed between 1,000 and 3,000 gausses
3. Loop ± 300 gausses superposed between 2,400 and 3,000 gausses

Fig. 2. Hysteresis loops for grade A silicon steel annealed 4 hr at 1,900 deg F, and cooled in furnace

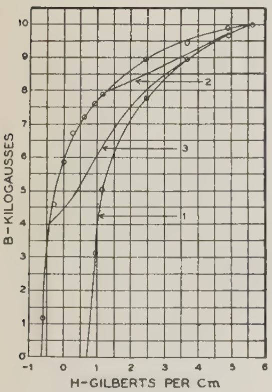


Fig. 3. Hysteresis loops for grade A silicon steel annealed 4 hr at 1,900 deg F, and cooled in furnace

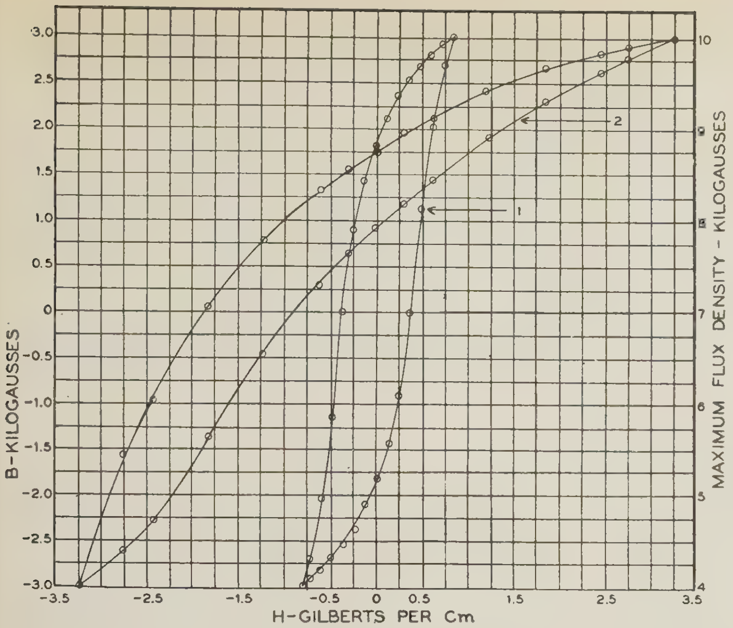
1. Half of normal loop, 10,000 gausses
2. Loop ± 1,000 gausses superposed between 8,000 and 10,000 gausses
3. Loop ± 3,000 gausses superposed between 4,000 and 10,000 gausses

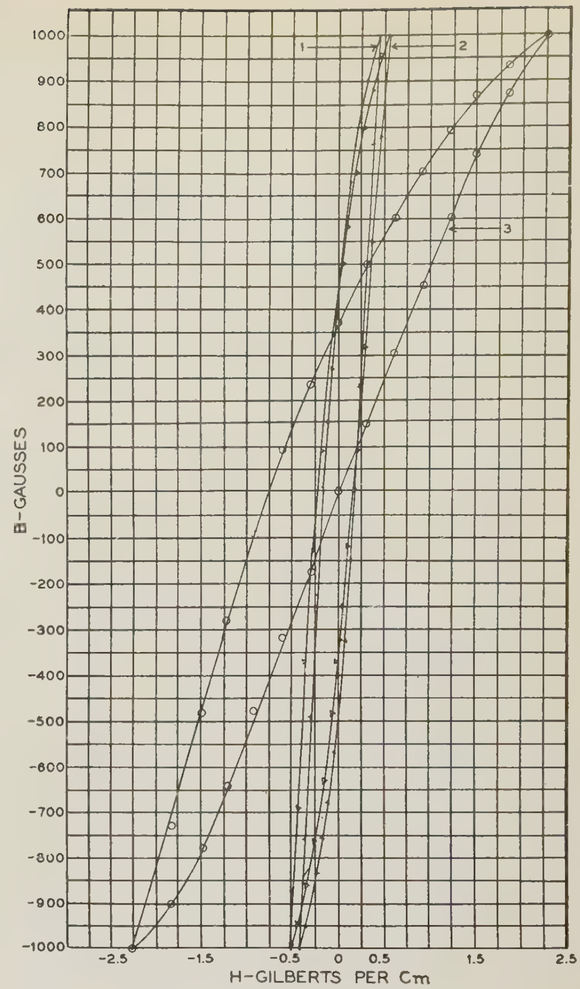
Experimental Procedure

Data for both symmetrical and unsymmetrical hysteresis loops were obtained by the ballistic galvanometer method on laminations of sheet steel 0.014 in. thick and an iron section of 1 sq in. They were assembled as a transformer using lapped laminations in form of a closed shell with the center leg or tongue cut once across for assembly purposes. The transformer was wound with 4 windings to make possible a high sensitivity for both major and minor loops. The error in the permeability caused by neglecting the slight air gap due to cutting of the tongues was carefully measured by comparing with laminations where the tongues had not been cut and was found to be not over 3 per cent for permeabilities

Table I—Hysteresis Losses in Silicon Steel for Normal or Symmetrical Loops

Flux Density, Gausses	Hysteresis Losses in Ergs Per Cu Cm Per Cycle						
	Grade A: Silicon, 4.65%		Grade B: Silicon, 3.23%			Grade C: Silicon, 1.18%	
	Unannealed	Annealed at 1,900° F	Unannealed	Annealed at 1,300° F	Annealed at 1,900° F	Unannealed	Annealed at 1,900° F
100	0.394	0.318	0.2915	0.46	0.393	0.855	0.64
300	3.36	3.15	4.26	3.96	3.72	7.35	5.55
600	13.5	14.55	17.45		13.0	27.2	20.7
1,000	41.2	45.0	39.8	37.2	35.8	74.0	58.1
3,000	265.0	302	296	241.0	231	469	347.7
6,000	832.5	930	1,010	747.0	780	1,335	990.7
10,000	2,010.0	2,130	2,240	1,910	1,717	3,288	2,323.6
13,000	3,300.0	3,912	3,500	3,980	2,600	5,733	3,835.6
15,000	4,930.0	5,725	6,140	7,650	5,550	7,404	5,093
W_h in watts =	$125\times10^{-13}\,vfB^{1.81}$	$200\times10^{-13}\,vfB^{1.77}$	$100\times10^{-13}\,vfB^{1.85}$	$116\times10^{-18}\,vfB^{1.82}$	$130\times10^{-13}\,vfB^{1.79}$	$250\times10^{-13}\,vfB^{1.79}$	$360\times10^{-13}\,vfB^{1.71}$





Figs. 4 (above) and 5 (right). Hysteresis loops for grade A silicon steel, unannealed

Fig. 4 (above)

1. Normal loop, 3,000 gausses
2. Loop ± 3,000 gausses superposed; maximum flux density 10,000 gausses

Fig. 5 (right)

1. Normal loop, 1,000 gausses
2. Loop ± 1,000 gausses superposed; maximum flux density, 3,000 gausses
3. Loop ± 1,000 gausses superposed; maximum flux density, 10,000 gausses

up to 11,000. This corresponds to an equivalent air gap of 0.00002 in.

Samples of silicon steel were classified into grades *A*, *B*, and *C*. Grade *A* or high-silicon steel contained 4.65 per cent silicon; grade *B* or medium-silicon steel, 3.25 per cent; and grade *C* or low-silicon steel, 1.18 per cent.

Normal hysteresis loops were taken at various flux densities from 100 to 15,000 gausses for each grade, first unannealed and then annealed at 1,900 deg F. Of course, the material called unannealed had received the ordinary anneal by the manufacturer before shipment. In addition, grade *B* was annealed at 1,300 deg F and 1,475 deg F before annealing at 1,900 deg. The annealing was done by heating the sample in a covered and sealed annealing box placed in an electric furnace at the required temperature for 4 hr and then letting it cool in the furnace.

Data for unsymmetrical loops were taken by keeping the maximum flux density constant at values of 3,000 and 10,000 gausses for each grade and in addition at values of 6,000, and 13,000 gausses for grade *B*. For 3,000 gausses maximum density, minor loops of ±100, ±300, and ±1,000 gausses were taken. The upper tip of the displaced loop corresponded with the upper tip of the major loop as shown by Figs. 2 and 3. This would mean that a minor loop of ±100 was superposed on an average of 2,900 gausses, a minor loop of ±300 on an average of 2,700 gausses, and a minor loop of ±1,000 on an average of 2,000 gausses. For 6,000 and 10,000 gausses maximum flux density, minor loops of ±100, ±300, ±1,000, and ±3,000 gausses were taken; and for maximum of 13,000, minor loops of ±300, ±1,000, ±3,000, and ±6,000 gausses.

Results

A typical set of hysteresis loops obtained for grade *A* silicon steel is shown by Figs. 2, 3, 4, and 5; similar loops were obtained for grades *B* and *C*. These curves show how the minor loops were superposed on major loops, and how their area and shape vary with displacement. Altogether about 200 such curves were obtained. Hysteresis losses computed from normal loops are given in Table I; those computed from displaced loops are given in Tables II, III, and IV.

From the normal hysteresis loops Steinmetz's formula was calculated for each material and anneal, by drawing the best straight line through the points obtained by plotting log W_h, against log B. Formulas obtained in this way are given in Table I; they check the measured values to within about 15 per cent or better. The largest errors are at the lowest densities. It was found that the average value of the exponent c is much nearer 1.8 than 1.6 as given by Steinmetz.

For maximum flux densities up to and including 6,000 gausses, the loss due to superposed loops can

Table II—Hysteresis Losses in Silicon Steel for Displaced Loops

Flux Density, Gausses		Hysteresis Losses in Ergs Per Cu Cm Per Cycle					
		Grade A: Silicon, 4.65%		Grade B: Silicon 3.23%		Grade C: Silicon 1.18%	
Maximum	Superposed	Unannealed	Annealed at 1,900° F	Unannealed	Annealed at 1,900° F	Unannealed	Annealed at 1,900° F
3,000	100	0.53	0.381	0.52	0.494	1.0	0.732
3,000	300	4.72	4.37	4.82	4.54	9.35	6.82
3,000	1,000	43.9	47.2	42.8	41.2	82.0	62.0
W_h in watts =		$86 \times 10^{-13}\, vfB^{2.06}$	$33 \times 10^{-13}\, vfB^{2.05}$	$88 \times 10^{-13}\, vfB^{1.90}$	$55 \times 10^{-13}\, vfB^{1.97}$	$120 \times 10^{-13}\, vfB^{1.96}$	$124 \times 10^{-13}\, vfB^{1.9}$

Table III—Hysteresis Losses in Silicon Steel for Displaced Loops

Flux Density, Gausses		Hysteresis Losses in Ergs Per Cu Cm Per Cycle					
		Grade A: Silicon 4.65%		Grade B: Silicon 3.23%		Grade C: Silicon, 1.18%	
Maximum	Superposed	Unannealed	Annealed at 1,900° F	Unannealed	Annealed at 1,900° F	Unannealed	Annealed at 1,900° F
10,000	100	0.945	1.05	1.0	1.06	1.47	1.55
10,000	300	11.05	11.4	11.5	12.35	18.45	15.7
10,000	1,000	92.4	103.0	94.4	101.5	164.0	118.5
10,000	3,000	406.0	440.0	404.0	328.0	618.5	447.6
W_h in watts =		$\dfrac{0.16\, vf}{\text{antilog}\,(12.6/\log B)}$	$\dfrac{0.192\, vf}{\text{antilog}\,(12.74/\log B)}$	$\dfrac{0.151\, vf}{\text{antilog}\,(12.5/\log B)}$		$\dfrac{0.276\, vf}{\text{antilog}\,(12.7/\log B)}$	$\dfrac{0.111\, vf}{\text{antilog}\,(11.9/\log B)}$

be represented by the Steinmetz formula expressed in the form

$$W_h = Kvf\,B^x \times 10^{-7} \tag{3}$$

where

W_h = watts hysteresis loss
K = constant
v = volume of iron in cu cm
f = frequency in cycles per second
B = flux variation superposed (lines per sq cm)

A separate formula was calculated for each test value of maximum flux density; these formulas are given in Table II at the bottom of the tabulated data to which they refer. It can be seen that the average value of exponent x in this case is much nearer to 2.0 than to 1.6 as given by Steinmetz (exponent c) or to 1.8 as obtained from data on normal hysteresis loops.

From loops superposed on maximum flux densities of 10,000 gausses or more, curves of type 1, Fig. 1, were obtained, when log W_h was plotted against log B, to calculate Steinmetz's formula. Since this formula is based upon a straight line relation, naturally it was found inadequate to express the results given by these curves. As explained before, not only the exponent x, but also the coefficient K for each point was different. It was found that if log W_h log B is plotted against log B as shown by curve 2, Fig. 1, a straight line can be drawn which passes much closer to the plots of measured points than if log W_h is plotted against log B (Steinmetz's formula).

This relation may be expressed mathematically as follows:

$$\text{Log } W_h \log B = A + C \log B \tag{4a}$$

Table IV—Hysteresis Losses in Grade B (3.23 Per Cent) Silicon Steel for Displaced Loops

Heat Treatment	Flux Density, Gausses: Maximum	Flux Density, Gausses: Superposed	Hysteresis Loss, Ergs Per Cu Cm Per Cycle	Formula W_h in Watts =
Unannealed	6,000	100	0.732	$144 \times 10^{-13}\, vfB^{1.86}$
	6,000	300	6.42	
	6,000	1,000	58.4	
	6,000	3,000	376.0	
Annealed at 1,300° F	6,000	100	0.747	$100 \times 10^{-13}\, vfB^{1.94}$
	6,000	300	7.07	
	6,000	1,000	54.8	
	6,000	3,000	267.0*	
Annealed at 1,900° F	6,000	100	0.575	$73 \times 10^{-13}\, vfB^{19.6}$
	6,000	300	5.86	
	6,000	1,000	52.6	
	6,000	3,000	261.0*	
Annealed at 1,300° F	13,000	300	19.9*	$\dfrac{0.059\, vf}{\text{antilog}\,(9.886/\log B)}$
	13,000	1,000	326.0	
	13,000	3,000	795.0	
	13,000	6,000	1,432.0	

*Formula does not hold at this density.

or

$$\log W_h = \frac{A}{\log B} + C$$

$$= C - \frac{-A}{\log B} \tag{4b}$$

or,

$$W_h = \frac{x}{\text{antilog}\,(-A/\log B)} \tag{4c}$$

where W_h and B have their former meanings, x is the antilog of the slope C of the line graph log W_h log B vs. log B, and A is the value of the Y-intercept.

The Y-intercept A is below the X-axis, so A is negative number. In order to avoid dealing with antilogs of negative numbers, the term $+(A/\log B)$ in the numerator of eq 4b is changed to $-(A/\log B)$ so that $(-A)$ becomes a positive number. This equation gives the loss in ergs for one cubic centimeter at a frequency of one cycle per second. To get the loss in watts for any structure, worked at uniform density at any frequency simply multiply by $(vf \times 10^{-7})$ where v is volume of iron in cubic centimeters and f is the frequency in cycles per second. Then eq 4c may be written in the form

$$W_h = \frac{x\, vf \times 10^{-7}}{\operatorname{antilog}\left(\frac{-A}{\log B}\right)} \tag{4d}$$

Within the limits of the test, the average value of A was found to be -12.3 and of C 6.15, which happens to be just half of the absolute value of A. These formulas are given in Table III at the bottom of the tabulated data to which they refer.

Discussion of Results

This investigation, besides bearing out almost all the important conclusions of the previous investigators on hysteresis losses in sheet steel due to displaced loops, brings out several new points of importance and interest.

"The hysteresis loss in sheet steel does not follow the Steinmetz law when the material is unsymmetrically magnetized, since both the coefficient and exponent of the familiar equation $W = n(B/2)^{1.6}$ are found to change with displacement; the coefficient increasing and the exponent decreasing with increase of displacement," was the conclusion of Chubb and Spooner from their investigation.[2] Within the range of the test the present writer finds that the hysteresis loss of loops superposed on maximum flux densities up to and including 6,000 gausses can be represented by an equation of the same form as that of Steinmetz as shown in Table IV, since the plot of log W_h against log B(pulsating induction) on ordinary cross-section paper gives approximately a straight line. The coefficient and exponent are both nearly constant for each maximum flux density. They are found to change, however, when the same pulsating inductions are superposed on different maximum flux densities. As seen in Table V, the coefficient increases and the exponent decreases as maximum flux density is increased.

The hysteresis loss due to loops superposed on maximum flux densities of 10,000 gausses or more cannot be represented by Steinmetz's equation. Equation 4 was derived to express the results obtained from all 3 grades of silicon sheet steel, both unannealed and annealed. The values calculated with this equation check much closer with the observed values, than those calculated with Steinmetz's equation or Ball's equation.

The displacement factor (the ratio of the area of a displaced loop to the area of a symmetrical loop of equal amplitude) for low-, medium-, and high-silicon steels, both unannealed and annealed, varies greatly between different steels at the same pulsating induction and maximum flux density. In other respects it follows certain marked regularities, e. g., for the same sample and the same pulsating induction, it increases consistently with maximum flux

Table V—Change in Coefficient and Exponent of Steinmetz's Formula With Maximum Flux Density for Grade B (3.23 Per Cent) Silicon Steel

Heat Treatment	Max. Flux Density* 3,000 Gausses		Max. Flux Density* 6,000 Gausses	
	Coefficient	Exponent	Coefficient	Exponent
Unannealed	88.0	1.90	144	1.86
Annealed at 1300° F	62.5	1.96	100	1.94
Annealed at 1900° F	55.0	1.97	73	1.96

*Superposed Flux Densities, ±100, ±300, ±1,000 gausses.

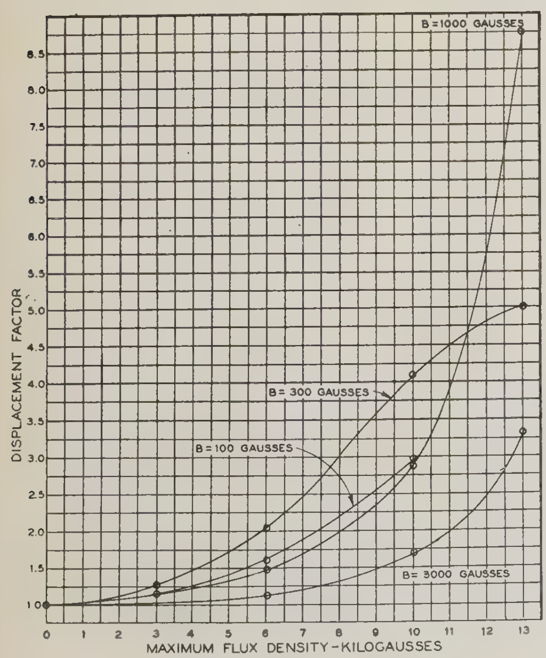
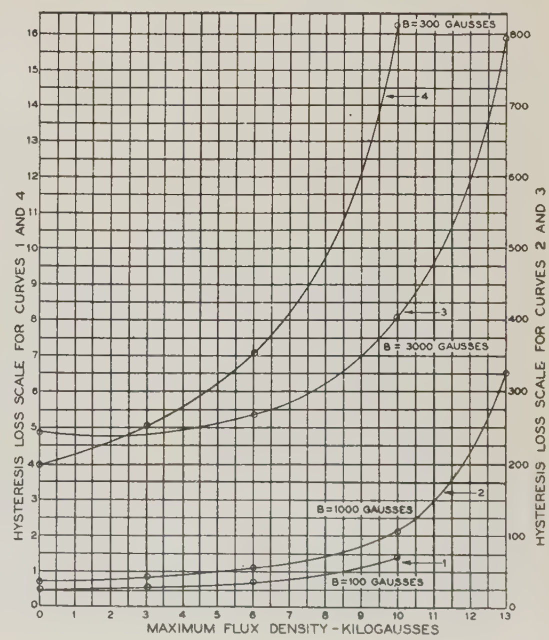


Fig. 6 (left). Maximum flux density vs. displacement factor for grade B silicon steel annealed at 1,300 deg F

Fig. 7 (right). Maximum flux density vs. hysteresis loss due to pulsating induction in grade B silicon steel annealed at 1,300 deg F

Superposed flux densities indicated on respective curves



density as shown in Fig. 6. This means that the hysteresis loss due to pulsating induction increases with maximum flux density, which is quite in agreement with the results shown in Fig. 7. Also, as shown in Fig. 8, for the same maximum flux density and all 3 grades of steel, both unannealed and annealed, the displacement factor increases rapidly at low pulsating inductions, reaches a maximum, and then decreases as the inductions are increased. The general shape of the curves appears similar to that of permeability curves. For maximum flux densities up to and including 10,000 gausses, the displacement factor showed a maximum for about 300 gausses superposed flux density. In other words, for maximum flux densities up to and including 10,000 gausses, the hysteresis loss due to pulsating inductions increases rapidly, reaches a maximum at about 300 gausses, and then decreases as the inductions are increased.

As the displacement factor in all cases is found to be greater than one, the hysteresis losses in silicon sheet steel due to displaced loops varying from ±100 to ±6,000 gausses are evidently greater than those due to symmetrical loops of the same amplitude. This, however, is not true of 50 per cent nickel steel. As shown in Fig. 9, the displacement factor for minor loops of ±100, ±300, and ±1,000 gausses is less than one; above this flux density it is greater than one. That is, the hysteresis losses in 50 per cent nickel steel due to such pulsating inductions, when superposed on maximum flux densities at least up to 6,300 gausses, are less than those due to normal loops of the same amplitude.

Conclusions

Principal findings of this investigation are as follows:

1. In common with the results of other investigators, the data here shown indicate that Steinmetz's theory for hysteresis loss in many instances is inaccurate and that its greatest errors occur at very high and very low flux densities.

2. Hysteresis loss in silicon sheet steel due to loops superposed on maximum flux densities up to and including 6,000 gausses can be represented by an equation of the same form as that of Steinmetz. The coefficient and exponent are both nearly constant for each maximum flux density; they are found to change only when given pulsating inductions are superposed on different maximum flux densities. For the displaced loops the value of exponent c is much nearer 2.0 than 1.6 as given by Steinmetz.

3. Hysteresis loss due to loops superposed on maximum flux densities of 10,000 gausses or more cannot be represented accurately by equations previously published. Equation 4 was derived to express the relation between hysteresis loss and pulsating induction superposed on flux density of 10,000 gausses or more and was successfully applied to all results presented here. The values of constants A and C derived for the samples annealed at 1,900 deg F apply to material which was somewhat oxidized. Where the material tested was unannealed, the oxidation should be negligible. Also, the samples tested differ in form from those that have been used by most of the other investigators; this investigation was made on laminations in form of a closed shell with the center leg cut once across for assembly purposes, whereas the previous investigations had been made mostly on samples in form of a ring.

4. The displacement factors for low-, medium-, and high-silicon steels, both unannealed and annealed, differ widely from one another at the same pulsating induction and maximum flux density.

5. For the same grade of steel and the same pulsating induction, the displacement factor increases with an increase in the maximum flux density.

6. For the same maximum flux density and all 3 grades of steel, both unannealed and annealed, the displacement factor increases rapidly at low pulsating inductions, reaches a maximum, and then decreases as the inductions are increased. For maximum flux densities up to and including 10,000 gausses, the displacement factor showed a maximum for about 300 gausses superposed flux density.

7. For all grades of silicon steel, both unannealed and annealed, and all superposed loops, the displacement factor is greater than one.

8. For 50 per cent nickel steel and superposed loops of ±100, ±300, ±1,000 gausses, the displacement factor first decreases, reaches a minimum, and then increases as the maximum flux density is increased. It is less than one up to 6,300 gausses and greater than one above that density.

Bibliography

1. Untersuchungen uber Magnetische Hysteresis, F. Holm. *Zeitschrift des Vereins Deutscher Ingenieure*, Oct. 1912, p. 1746–51.

2. The Effect of Displaced Magnetic Pulsations on the Hysteresis Loss of Sheet Steel, L. W. Chubb and Thomas Spooner. A.I.E.E. Trans., v. 34, 1915, p. 2671–92.

3. The Unsymmetrical Loop, John D. Ball. A.I.E.E. Trans., v. 34, 1915, p. 2693–2715.

4. Tooth Frequency Losses in Rotating Machines, Thomas Spooner. A.I.E.E. Journal, v. 40, 1921, p. 751–6.

5. Magnetic Properties of Sheet Steel Under Superimposed Alternating Field and Unsymmetrical Hysteresis Losses, Yasugiro Niwa and Yoshihiro Asami. Dept. of Communication, Tokyo, Japan, *Researches of the Electrotechnical Laboratory*, June 1923, p. 124.

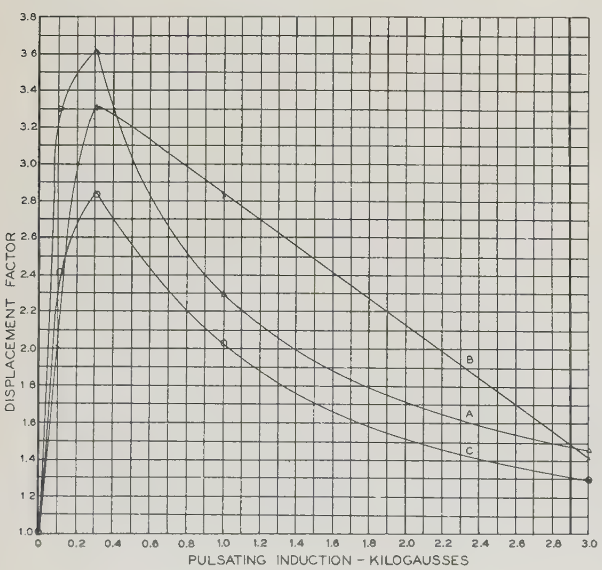
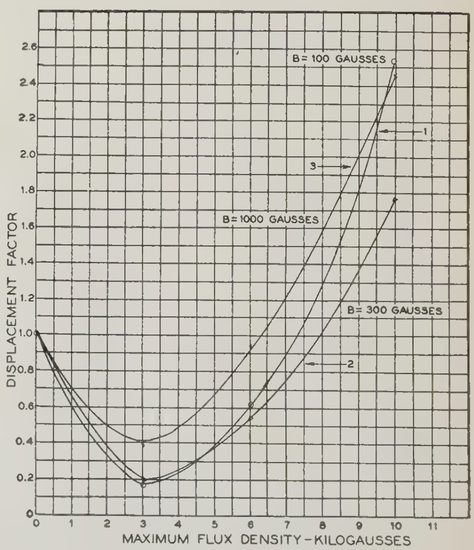


Fig. 8 (left). Pulsating induction vs. displacement factor for maximum flux density, 10,000 gausses; grades A, B, and C silicon steel

Fig. 9 (right). Relation between displacement factor and maximum flux density for 50 per cent nickel steel annealed at 1,650 deg F for 2 hr, cooled in furnace to 975 deg F and then in air



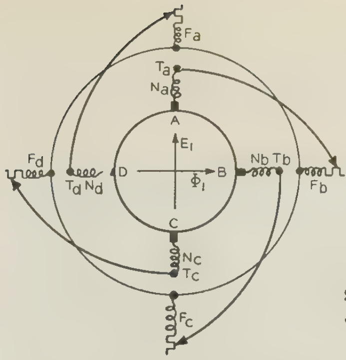
Superposed flux densities indicated on curves

A Generator for Low Frequencies

A practical source of alternating current at low frequency now is available for moderate cost. This generator is of the self-exciting commutator type. A description of its application, theory, and actual performance is included in this article.

By
J. I. HULL
MEMBER A.I.E.E.

General Electric Company,
West Lynn, Mass.



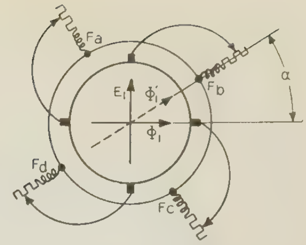


Fig. 2 (above). Polyphase self-excitation at a frequency value other than zero (alternating current)

Fig. 1 (left). Polyphase self-excitation at zero frequency (direct current)

A SELF-EXCITING commutator generator has been developed as a source of power having a frequency of 2.5 cycles per sec. A successful generator of this type seems sufficiently novel to warrant a description of its fields of application and its fundamental theory.

Since the output of a synchronous generator of 25 cycles or less is seriously limited by its speed, low frequency applications will be the most attractive for the commutator generator, the more so, as commutating conditions are easier the lower the frequency. If the frequency could be altered independently of the speed, the fields of application would be broadened. The number of likely specific applications for a very low frequency power source is considerable and appears to be increasing. Typical examples needing an auxiliary constant voltage and constant low frequency supply are such machines as printing presses and super-calenders for paper mills, where it is desired to operate induction (or synchronous) motors for adjusting or "barring" at very low, yet stable speeds. Another possibility is presented by the drive of rolling mill table roll motors, which for the service conditions can be best built for low frequency. Certain vibratory devices are best operated by 10-cycle or 15-cycle power. Moreover, new possibilities might be opened up for frequently reversing motors, by the use of suitable progressive or continuous changes of both voltage and frequency, whereby reversals can be attained with less time and energy loss. Still another type of application is the drive of a group of machines requiring to be synchronized at all times even during starting, stopping, and rest, the members of which might be each actuated by a synchronous motor, all these motors driven in common from continuously varying voltage and frequency. The frequency should pass through zero with a stable minimum voltage of appropriate value for best working conditions. This increasing number of varied likely possibilities caused the writer and his associates to undertake to make what is possibly the first commercial use of a self-exciting a-c commutator generator as the prime source of energy for a power machine.

Essentially full text of "Low Frequency Self-Exciting Commutator Generator" (No. 33-34) presented at the A.I.E.E. winter convention, New York, Jan. 23–27, 1933.

Self-Excitation in a Completely Neutralized Machine

A machine having the armature reaction completely neutralized is suited to give the variety of characteristics and the excellence of commutation needed even for pressures up to several hundred volts. This construction is common for heavy duty d-c apparatus and in a-c commutating apparatus for the speed and load control of large induction machines. To illustrate the principle, the circle in Fig. 1 represents an ordinary 100 per cent pitch 2-pole d-c type commutator armature provided with 4 brushes A, B, C, and D, spaced 90 deg. Series neutralizing windings N_a, N_b, N_c, and N_d exactly neutralize the magnetizing effect of the rotor current and cancel any transformer voltage developed in the armature by changes of the flux, so that between terminals T_a, T_b, T_c, and T_d there appears only the voltage due to rotation. It is proportional to the rate of rotation, amount of flux, and a constant of the machine, and independent of frequency.

Assume the existence of a flux Φ_1 in direction DB. Its resulting rotation voltage E_1 is in direction CA which is 90 deg in space from DB. If the resistance of the circuits of F_b and F_d permits E_1 to circulate a current having the magnetizing force required for Φ_1 a steady state exists, since there is no voltage between B and D and no current in F_a and F_c (that might tend to change the flux). Voltage stability depends upon the saturation effect of the magnetic circuit as in a d-c machine. With Φ_1 assumed in direction AC, a similar steady condition would exist, E_1 being in direction DB and exciting current flowing in F_c and F_a instead of F_b and F_d.

If Φ_1 is displaced not necessarily 90 deg but any angle x from the position drawn, then the voltage in direction CA is $E_1 \cos x$ while that in direction DB is $E_1 \sin x$. Field currents will exist in the windings of corresponding axes in similar proportions and give the same resultant total magnetizing force as before but shifted by the angle x from its former direction.

Thus the machine can operate equally well and will be stable with flux in any axis. In this poly-axial condition, even with direct current, the system can be regarded as a true polyphase one whose frequency is zero.

Such a machine with the neutralizing windings (though assumed to exist) omitted from the drawing for simplicity is represented in Fig. 2. However, the exciting windings F_a, F_b, F_c, and F_d instead of being arranged to act 90 deg from the rotation voltage axis are now assumed to be rotated α deg in the machine from that position. The rotation voltage E_1 due to flux Φ_1 would thus when acting alone not tend to support the flux Φ_1 but the flux Φ_1' shifted α' from Φ_1. If the resistance of the exciting circuits be decreased to cos α times its former value, Φ_1' has a component $\Phi_1' \cos \alpha$ equal to Φ_1 in magnitude and direction, so there can be no collapse of voltage. But the out of phase component $\Phi_1' \sin \alpha$ indicates a field rotating at infinite velocity, as the assumed flux Φ_1 sustains, at the same time, not only itself but also a component in advance of itself in space, thus advancing E_1 at the same time. Any rotation of the flux, however, will result in the generation of transformer (or reactive) voltages in the exciting windings. With a steady state these cause the exciting current to lag just enough to magnetize at every instant in the (changing) direction of Φ_1 rather than that of Φ_1'. At some particular frequency a stable state with a continuously revolving field can exist, because the component of E_1 which remains to balance the IR drop is E_1 cos of angle of time lag (which angle must of course be equal to α); with our new value of field circuit resistance reduced in ratio of cos α to 1, this component of E_1 will just circulate the field current needed to sustain Φ_1. The diagram of Fig. 3 has been drawn in order to find the relations between the voltage, frequency, speed, number of exciting turns, and axis shift of the exciting winding from its zero frequency or d-c position. The following equations may be written:

$$e_T = E_1 \sin \alpha \tag{1}$$

$$E_1 = \Phi_1 (rpm) K \tag{2}$$

$$e_T = 4.44\, \Phi_1 \sim N_1 10^{-2} \tag{3}$$

where

E_1 = rotation voltage
e_T = transformer voltage in exciting winding
α = axis shift and time lag angle
Φ_1 = working flux
$\sim$ = frequency
N_1 = field winding turns
K = machine constant

Substituting eq 2 in eq 1 in eq 3

$$\sim = \frac{K_2 (rpm) \sin \alpha}{N_1}$$

where

$$K_2 = \frac{K\, 10^2}{4.44} \tag{4}$$

The interesting fact is noticed that the frequency is dependent only upon speed (rpm), angle of axis shift, number of turns in exciting winding, and a constant K_2. (K_2 depends upon the number and disposition of rotor conductors.)

The following equation may also be written for the field circuit resistance drop

$$ir = E_1 \cos \alpha \tag{5}$$

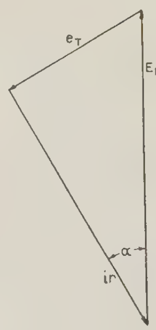
where

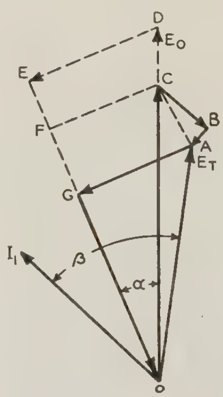
i = field circuit current
r = field circuit resistance

This is of the same form as for the shunt field circuit of a d-c machine. So it may be concluded that, as in a d-c generator, the voltage can be adjusted by changing resistance in series with the shunt field winding, without in any way affecting the frequency. The stability of the voltage, at a given setting, as with a d-c generator is dependent upon saturation. The condition of self-excitation with a d-c generator is that the resistance drop of the exciting current of a given flux be not more than the rotation voltage of that flux. With the a-c machine the condition is that the resistance drop be not greater than the rotation voltage times the cosine of the angle of axis shift or,

$$ir \lesseqgtr E_1 \cos \alpha \tag{6}$$

Were it possible suddenly to alter α, the frequency corresponding to the new position (if eq 6 is satisfied for any voltage) should be assumed at once, but if the new condition requires a different magnitude of voltage, the change of magnitude should be gradual as is the case with a d-c generator. So, to initiate self-excitation, the priming flux has theoretically any finite magnitude and frequency; upon release from the priming flux energy source, the machine promptly assumes its normal frequency and gradually assumes its normal voltage. These anticipated characteristics were verified by tests, during which residual flux often proved a sufficient prime to initiate self-excitation.





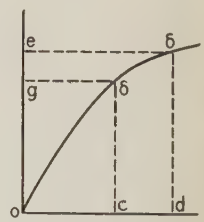


Fig. 5 (above). Saturation curve

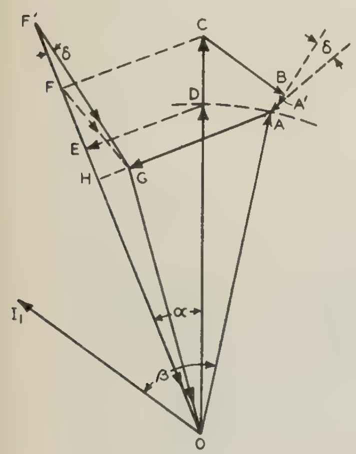
Fig. 3 (left). Field circuit relations

Fig. 4 (middle). Shunt self-excitation unloaded and loaded

Plain Shunt Excitation

Since the foregoing formulas are exact only if the rotation voltage E_1 and terminal voltage E_T are identical, it is of interest to consider the performance, not only running light but also when a load current is

taken off, as this will introduce a difference between the generated and the terminal voltage. In Fig. 4 we have shown relations in a plain shunt excited machine. The running light condition is similar to Fig. 3, generated voltage E_1 being OD, reactive field drop or transformer voltage of the flux being DE and field circuit resistance drop being EO. CB and BA are resistance drop and reactance drop of load current I_1, and the resultant terminal voltage OA will evidently be less than OD. If the working flux is by this fact reduced, OC, the generated voltage will be less than OD. The angle α remains constant at



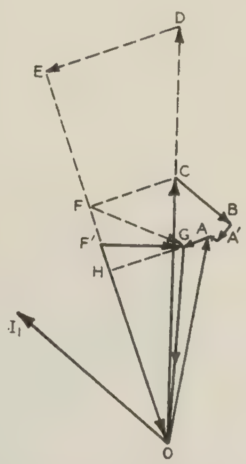


Fig. 6 (left). Self-excitation loaded and unloaded, flat compounded as to both voltage (OA/OD) and frequency (AG/CF)

Fig. 7 (right). Self-excitation loaded and unloaded, compounded for falling voltage (OA/OD) and falling frequency (AG/CF)

all steady states of excitation, as does the angle between AG (or DE or CF) and OCD. (Note that α is the "axis shift angle" no longer equal to the power factor angle of the field impedance drop.) It is evident, then, first that stability obtains when the relations between OD, OE, OC, and OG, are as shown in the saturation curve, Fig. 5, for the corresponding quantities od, oe, oc, and og, and in which oe = magnetizing current for no-load generated voltage od, and og = magnetizing current for full load generated voltage oc (the field current resistance drops OE and OG are proportional to field current oe and og). Secondly it can be seen that the ratio of AG to OC is a measure of the frequency, since with constant speed OC is proportional to the working flux while AG is proportional both to this flux and to its frequency (being an induced voltage). Since $\frac{CF}{OC} = \frac{DE}{OD}$ it follows that

$$\frac{AG}{CF} = \frac{\text{frequency loaded}}{\text{frequency unloaded}}$$

As drawn, the frequency has somewhat increased and the voltage has decreased as the load current I_1 came on. Had the angle of lag β of I_1 behind OA been a certain amount less, CA would have been parallel to FG, AG would have been equal to CF, and the frequency would not have changed at all. With a still less reactive component in the load current, or a pure watt load or a capacity load, the frequency decreases with load.

Compound Excitation for Constant Voltage and Frequency

These variations of voltage and frequency can be magnified or reduced, and for any particular load condition can be eliminated entirely by compounding. In Fig. 6 is illustrated a condition of flat compounding wherein a series excitation has been added so as to maintain the same terminal voltage and the same frequency with the load current I_1 as at no load. Thus OA, terminal voltage with machine loaded, is numerically equal to OD, no-load generated and terminal voltage, and is the resultant of OC, the generated voltage with machine loaded, and the reactance and resistance drops BA and CB of the load current I_1. The "reactance drop" BA is defined as the true reactance drop BA' plus the voltage $A'A$ generated in the series exciting winding by transformer action of the main flux. In the shunt exciting circuit, the induced voltage AG at a constant angle (90 deg + α) from OC must equal CF in order, with flux corresponding to OC, to have the same frequency as at no load (measured by $DE/OD = CF/OC$). Thus the resistance drop GO (and so the shunt field current) is neither of correct phase nor magnitude to excite the required flux for OC. If there were no saturation effect such a fictitious resistance drop would be FO, but as the iron density has risen, the shunt field current would have to be increased more than directly as OC/OD so that the actual resistance drop of the shunt field current that would be needed is represented by $F'O$. So, actually to have the requisite compounding there must be supplied in addition to the shunt exciting winding a series winding such that from I_1 will be derived the same ampere turns as would come from the shunt winding if it carried the current corresponding to drop $F'G$. The voltage induced by the working flux in such a series winding would be a plain reactance drop lagging 90 deg if there were no other ampere turns in the circuit, but since the actual total ampere turns are proportional to $F'O$ which is δ deg out of phase with $F'G$, the "reactance drop" of the series winding is shown as $A'A$, shifted δ deg from BA', the true leakage reactance drop.

The series excitation required for flat compounding of both voltage and frequency serves the purpose of supplying that excitation needed to generate a voltage to overcome the resistance and "reactance" drop of the main circuit, and save for the variations of saturation effect would (neglecting AA') be correct for constant terminal voltage and frequency with all values of load current I_1 as well as for the particular one illustrated.

Compound Excitation for Falling Voltage and Frequency

The diagram of Fig. 7 is drawn to illustrate voltage and frequency simultaneously decreased with

load I_1, by suitable compounding. The no-load generated and terminal voltage is OD, full load generated voltage OC, and terminal voltage OA. No-load frequency is measured by $DE/OD = CF/OC$ and full load frequency is measured by AG/OC; hence as load changes from zero to I_1,

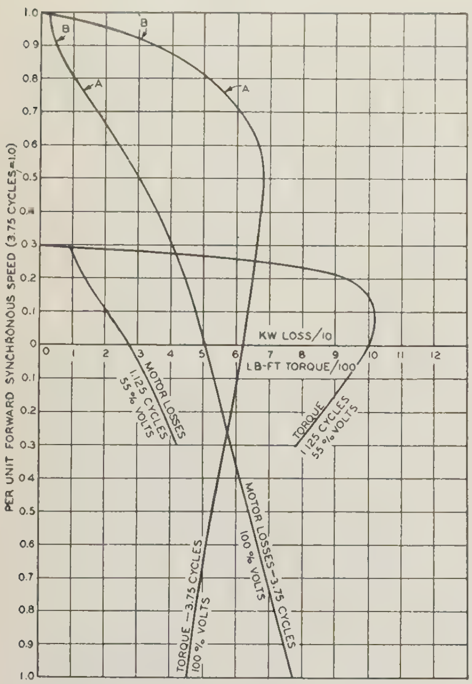


Fig. 8. Motor performance with 2 sets of voltage and frequency conditions

voltage changes from OD to OA and frequency from CF to AG. The compounding effect can be chosen so that percentage change in frequency is more or less than the change in voltage as desired.

In this case the generated voltage OC being less than the no-load value OD, there is required an equivalent shunt field resistance drop $F'O < FO$ because of decreasing saturation, hence the needed series winding effect will correspond to resistance drop $F'G$ and not FG.

As is the case when voltage of a d-c generator is varied by field resistance manipulation or by series windings, there is a certain favorable voltage range as governed by the saturation curve of the machine in which the voltage and frequency can be stably manipulated as described above, but outside such range instability occurs. There are various ways beyond the scope of this article whereby the stable range may be so extended as to include very small voltage values even at zero frequency when desired, either with compound excitation or with adjusted shunt excitation, or both.

Reversal of Induction Motor by Voltage and Frequency Control

The curves of Fig. 8 have been calculated in order to show the advantage that could be obtained in a frequently reversing induction motor even at low running frequency, if it were reversed in several steps of both voltage and frequency rather than by "plugging." Speed-torque and speed-loss curves supply data for calculations (not reproduced here) to illustrate this point. It is found that with a fixed value of 100 per cent volts and 3.75 cycles, a certain motor whose inertia is WR^2 can be "plugged" from + 90 per cent to −80 per cent speed in 1.7 sec with an internal loss of 76.7 kw-sec and the effective torque value is 560 lb-ft. If the reversal is obtained by passing in steps from 100 per cent volts, 3.75 cycles to 55 per cent volts 1.125 cycles, then to 55 per cent volts 1.125 cycles reversed phase sequence and finally to 100 per cent volts 3.75 cycles, reversed phase sequence, the reversal can still be done in 1.7 sec but with an internal loss of 36 kw-sec, or 47 per cent as much internal heating as in plugging.

A similar study indicates that reversal by passing from forward rotation to direct current, then to backward rotation, would produce 64 per cent as much heating as straight plugging.

Still better reversal can be obtained if voltage and frequency are smoothly changed from one rotation to the other so as to have the motor always operate at a portion of its curve which yields large torque in proportion to losses. This process will best be comprehended by realizing that the torque and the I^2R losses (which will be the largest portion of the losses) are constant for given values of primary current and slip in revolutions per minute, irrespective of the actual speed, frequency, and voltage. So if voltage and frequency be varied suitably,

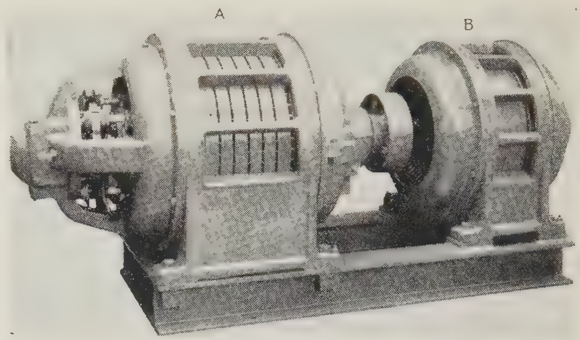


Fig. 9. The 40-kva 2.5-cycle frequency converter set

A. 40-kva 235-volt 2.5-cycle self-excited generator
B. Squirrel-cage induction driving motor

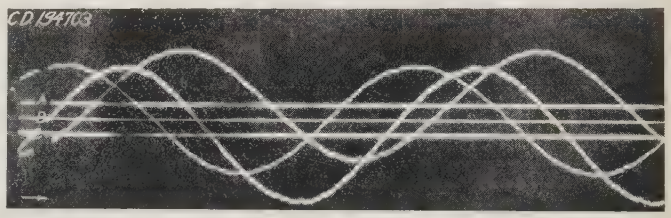


Fig. 10. Voltage wave form of generator while loaded

For this test, terminal voltage was 225 volts, and load current was 125 amp at low power factor (75 per cent) Rated current is 100 amp

the reversal can be carried out at a constant value of torque and loss selected from the motor curves, such as points *AA*, Fig. 8, wherein the torque is 560 lb-ft, and the losses 13 kw. The time still being 1.7 sec, the heating can be found to be $1.7 \times 13 = 22.1$ kw-sec or 29 per cent of that due to straight plugging.

At points *BB*, torque is 300 lb-ft, time is 3.17 sec, losses are 4.5 kw, and kw-sec are 14.25 or 18.7 per cent of the heating due to plugging.

Neglecting saturation, the time of a reversal can be adjusted by using more or less voltage without affecting the stored heat losses, since both torque and losses vary approximately as the square of the voltage. So, when not operating within zones of high saturation it may be advantageous to operate much below the maximum torque point, or at points *BB*, securing the desired speed of reversal by the use of a higher voltage.

Performance Records of a Commercial Machine

An actual self-exciting generator of the type described has been constructed and tested. It is a 6-pole 1,200-rpm 3-phase machine rated 40 kva, 235 volts, 2.5 cycles, and driven by a squirrel-cage induction motor. The set is shown in Fig. 9, *A* being the self-excited generator, *B* the driving motor. The function of this set is to supply 2.5-cycle 235-volt power to one or more 200-hp super-calender induction motors in order to secure threading operation at very low stable speed. The generator was compounded for approximately flat voltage and frequency as described in connection with Fig. 6, and but very slight changes with load of either voltage or frequency were present after the correct operating brush position was obtained. Commutation was excellent. The voltage wave form was very acceptable as shown in Fig. 10, although no special study of this detail was made.

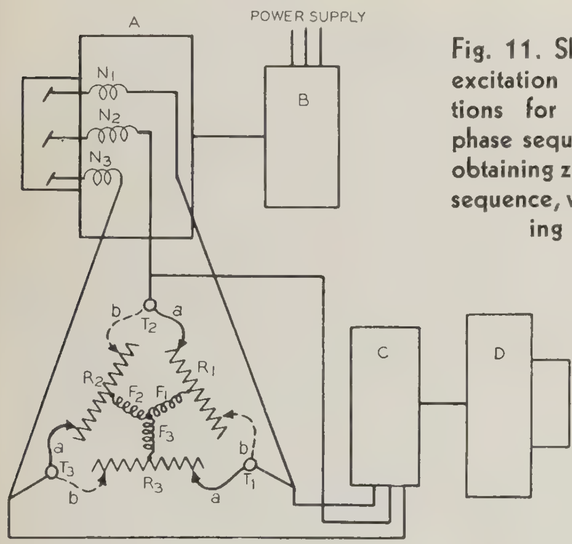
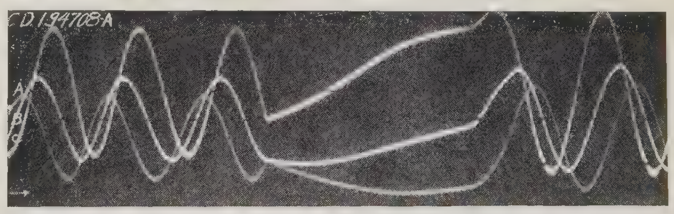


Fig. 11. Shunt self-excitation connections for reversing phase sequence and obtaining zero phase sequence, with loading set C-D

The simple arrangement used for obtaining various voltages and frequencies of both phase sequences as well as zero phase sequences (direct current) is shown in Fig. 11. *A* is the low frequency generator, *B* its driving motor, *C* is a 200-hp 480-rpm induction motor used as a power and reactive load for *A*. It is coupled to a heavier d-c generator *D* both for greater inertia and to be able to control the energy load. The connections are drawn for shunt excitation, 3-phase, compounding windings not shown. N_1, N_2, N_3 are neutralizing windings, F_1, F_2, F_3 the shunt exciting windings equipped with double ended rheostats $R_1R_2R_3$. When $F_1F_2F_3$ are connected through connections *aaa* the angle of axis shaft α of the exciting winding is +60 deg, and thus any balanced connection to the *a* ends of $R_1R_2R_3$ gives 2.5 cycles positive rotation; voltage depending upon amount of resistance. Connecting through *bbb* to the *b* ends of $R_1R_2R_3$, as shown, changes the axis shift α by 120 deg resulting in an axis shift of −60 deg, a frequency of −2.5 cycles (reversed phase sequence). If both the *a* and *b* connections are closed together with *a* and *b* resistances equal, the result is axis shift α equal to zero, and frequency equal to 0. If *a* and *b* resistances are unequal the direction of phase sequence is determined by the lower. By setting the *a* and *b* resistances equal, with a 3-pole switch (or contactor) in each branch we can change quickly from 2.5 cycles condition (*a* switch closed) to 0 cycles (*a* and *b* switches closed) to 2.5 cycles negative (*b* switch only closed).

In carrying out this manipulation as recorded in Figs. 12 and 13, a perfect balance was not obtained between the *a* and *b* ends of the rheostat so that the intermediate stage (both switches closed) gave a very low frequency rather than exactly zero frequency or direct current.

When the record shown in Fig. 12 was made, the machine was operated on normal phase sequence (*a* switches closed) and 200 volts 2.5 cycles up to a certain point at which the *b* switch was also closed giv-



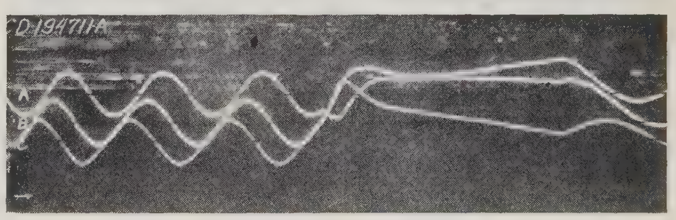
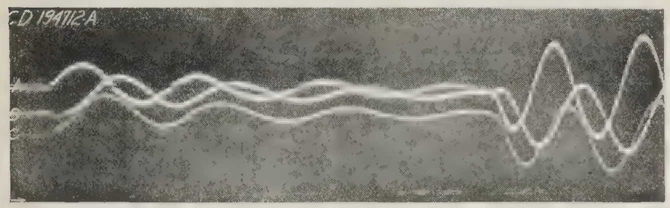


Fig. 12 (above). Open-circuit transition from forward phase sequence to approximately zero to reversed phase sequence

Fig. 13 (below). Loaded transition from forward phase sequence to approximately zero to reversed phase sequence

ing nearly 0 axis shift and phase sequence, until switch a was suddenly opened again changing the angle of field axis shift from approximately 0 deg to −60 deg and giving, as may be seen, reversed phase sequence. In Fig. 13 the same manipulation was carried out but the 200-hp 40-cycle induction motor C of Fig. 11 direct coupled to the much heavier d-c generator D was connected to the low frequency generator terminals throughout the test. The load set CD appeared to the eye to run smoothly up to the point of closing switch b, where it seemed to drop instantly to a speed nearly equal to 0, and then instantly to come up to speed in reverse direction when switch a was opened. The prompt response of the frequency to a change in the field circuits is shown clearly in Figs. 12 and 13.

Build-up of self-excitation by a rather large d-c impulse in the field circuit with field rheostat set for 200 volts is shown in Fig. 14, and Fig. 15 shows build-up with a very small d-c impulse and field rheostat adjusted for 280 volts. These are interesting as showing that the frequency assumes approximately its steady state value even during build-up. In Fig. 14 the duration of the impulse terminates where regular voltage waves commence, but in Fig. 15 the impulse is so weak that it is difficult to see just where it ceases. Very careful measurements of frequency with various rheostat settings and voltage also showed it to be independent of rheostat position and voltage. The expectation that self-excitation could be readily started by a small impulse in the field circuit of commercial frequency current either



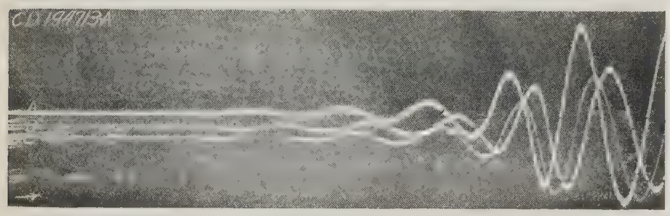


Fig. 14 (above). Establishment of self-excitation by a strong d-c impulse in field circuit

Fig. 15 (below). Establishment of self-excitation by a weak d-c impulse in field circuit

single phase or polyphase was also confirmed by test but no oscillograms taken.

Conclusion

This investigation indicates that a practical, flexible, and easily manipulated source of alternating current at frequencies below those advantageous for synchronous alternators is available for moderate cost. It can be controlled so as to serve the many needs known and likely to appear for energy in this form, and unlike various other types of frequency converters readily can be produced with good commutation up to several hundred volts.

Skin Effect in Rectangular Conductors

A method of measurement of skin effect in rectangular conductors is presented in this article, and experimental data are included which facilitate the calculation of the a-c resistance of such conductors at commercial frequencies.

By
H. C. FORBES
MEMBER A.I.E.E.

L. J. GORMAN
MEMBER A.I.E.E.

Both of the New York Edison Co., New York, N. Y.

Determination of the skin effect at commercial frequencies in solid conductors of rectangular cross section for cases where the return circuit is comparatively remote so that proximity effect need not be considered, was the initial object of the investigation discussed in this article. These specific conditions are approximated in the case of bus bars of rectangular conductors in generating stations and substations where an isolated phase layout is employed. It was in connection with the design of such buses that the need for more complete information developed. In the process of obtaining the information desired, it was also possible to obtain basic data from which the skin effect in any non-magnetic rectangular conductor of ordinary dimensions can be determined readily for a wide range of frequencies.

Considerable work, both of an experimental and a theoretical nature, has previously been done on this subject. Particular mention is made of "Skin

Full text of a paper "Skin Effect in Rectangular Conductors" (No. 33-2) presented at the A.I.E.E. winter convention, New York, N. Y., January 23–27, 1933.

Effect in Tubular and Flat Conductors," by H. B. Dwight, Trans. A.I.E.E., v. 37, 1918, p. 1379–1400, and of "Experimental Researches on Skin Effect in Conductors," by A. E. Kennelly, F. A. Laws, and P. H. Pierce, Trans. A.I.E.E., v. 34, 1915, p. 1953–2018, and of the accompanying discussion, particularly that contributed to the first of these 2 articles by Joseph Slepian.

It has been shown in these papers that the ratio of a-c to d-c resistance of a conductor may be determined as a function of the parameter:

$$P = \sqrt{\frac{8\pi f A}{\rho}}$$

where
f = frequency in cycles per second
A = area of cross section in square centimeters
ρ = specific resistivity in abohms per cm³
(specific resistance in ohms is $\rho \times 10^{-9}$)

This relationship suggested the possibility mentioned by Dwight of making tests at high frequencies on conductors of relatively small cross section and applying the results to obtain the skin effect in large conductors at lower frequencies. This scheme of testing obviously offers great advantages because of the difficulties in making a-c measurements at the very low voltages which would be involved if large size conductors were tested at commercial frequencies. Accordingly, in this investigation the above principle was applied to tests on small rectangular conductors of various width-to-thickness ratios, tested at frequencies ranging from 22 to 287 kc.

Two methods of measuring a-c resistance at high frequency were investigated; namely, the "substitution method" and the "resistance variation method," both of which are described in detail in the publications of the Bureau of Standards (see Bureau of Standards Circular No. 74). Essentially, each employs a test circuit, which includes the test specimen, coupled to a suitable source of high frequency current, such as a vacuum tube oscillator.

Substitution Method Used

For the particular low-resistance circuits involved in this investigation, the substitution method seemed to give the most satisfactory results and was best adapted to the use of the laboratory equipment on hand. In this method, it is not necessary to measure precisely the current or voltage, but only to provide a means of indication by which the electromotive force may be controlled, and the test current adjusted and held at a convenient value for a particular test. Furthermore, it was found that the introduction into the test circuit of any of the high frequency ammeters available added materially to the total resistance of the circuit, and thereby greatly decreased the sensitivity of the measurement. This proved to be a limitation in the use of the resistance variation method. The use of an ammeter in the substitution method was avoided by the current-indicating device described in the following paragraphs.

Although the method of measurement is relatively simple, there are various precautions incidental to the use of high frequency currents that must be observed in the practical application to avoid erroneous results. These precautions apply particularly to the shielding and grounding of the various parts of the test equipment, and to the measurement and control of the high frequency currents.

The oscillator and equipment used in the tests are shown in the schematic circuit diagram given in Fig. 1. Essentially, the equipment consisted of a master oscillator coupled to a 2-stage power amplifier, the second stage of which contained 2 50-watt electric tubes of the hot cathode vacuum type. The primary of an air core transformer was connected to the output circuit of the amplifier. Special care was taken in the construction of the oscillator and in the selection of tubes and other equipment to insure a wave shape as free of harmonics as possible. With the oscillator operating at frequencies between 20 and 180 kc, a test was made for harmonic frequencies up to 3,000 kc. No harmonics of importance were found within this range of frequency. Precautions were taken to avoid possible errors due to "proximity effects," "end effects," and the influence of metallic structures located near the test circuit. These various influences and their effect on the measurements were checked in a series of preliminary tests.

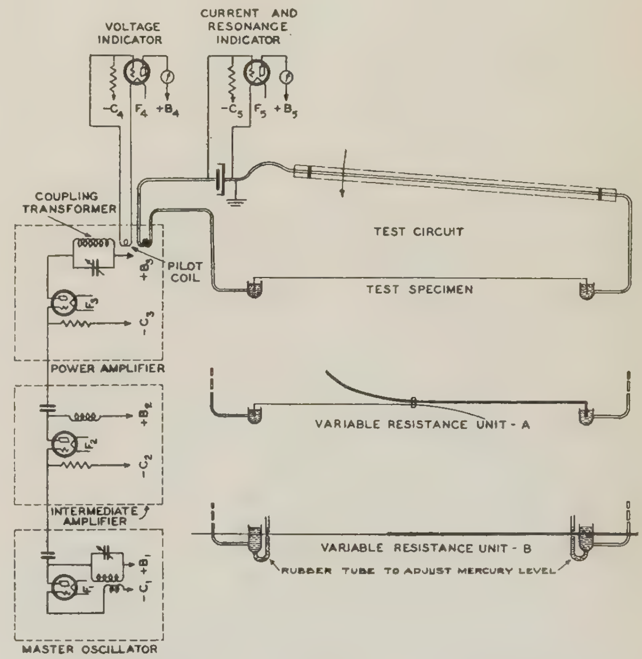


Fig. 1. Schematic diagram of oscillator and test circuits for skin effect measurements

Test Circuit

The test circuit shown in Fig. 1 comprises a loop containing the test specimen, a low-loss tuning condenser, and a length of heavy Litzendraht cable, required to complete the circuit. The oscillator coupling was made through a single turn of cable loosely coupled to the transformer primary. The conden-

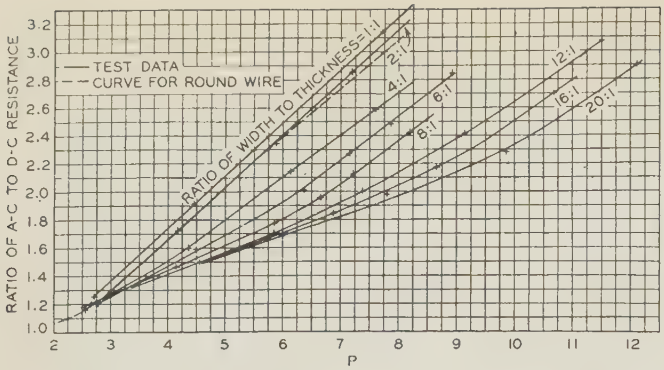


Fig. 2. Skin effect in strap copper conductors, expressed in terms of parameter *P*

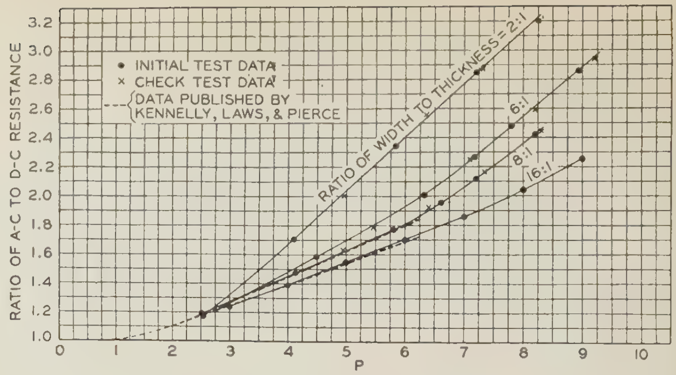


Fig. 3. Skin effect in strap copper conductors compared with previously published data

sers in the test circuit were selected with reference to the size of the loop, so that the circuit was approximately in resonance at the desired test frequencies. Adjustment for resonance was made by moving in or out the arm on one side of the loop, as indicated by the arrow in Fig. 1, thereby varying the size and inductance of the loop. This arrangement permitted a very fine adjustment of resonance, avoided the use of tuning coils, gave a test circuit of minimum resistance, and permitted the desired sensitivity in the measurements.

The electromotive force induced in the test circuit was determined by means of the voltage indicator shown in Fig. 1. This consisted of a pilot coil closely coupled to the secondary turn and connected to the grid circuit of a vacuum tube, as shown. The indications on the milliammeter in the plate circuit of the vacuum tube were proportional to the electromotive force induced in the pilot coil, and, since the same flux was interlinked with the secondary turn, the readings were proportional to the electromotive force induced in this turn. By means of the indicator, it was thus possible to maintain a constant resultant flux interlinked with the secondary turn, and, therefore, a constant electromotive force in the test circuit, by adjusting the plate voltage on the amplifier.

It was apparent that the resistance of the test circuit would have an important influence on the sensitivity of the measurement. The resistance of the circuit, not including the test specimen, was therefore kept as low as possible so that the resistance of the test specimen would constitute a large portion of the total circuit resistance. It was found that inserting an ammeter into the test circuit added appreciably to its resistance. Since in the method of measurement it is not essential to know the test current in amperes, the use of an ammeter was avoided by using a vacuum tube indicator, the grid circuit of which was connected across the fixed condenser in the test circuit, as shown in Fig. 1. Since at any given frequency the drop across the condenser would be proportional to the current, this gave a means of indicating the point of resonance and served as a basis for making the adjustment of the variable resistance required to give a current equal to that obtained when the test specimen was in circuit. This arrangement proved quite satisfactory. An approximate calibration of the indicator was made by connecting a low-resistance high-frequency ammeter in the circuit, and plotting readings on the indicator against ammeter readings at each of the various test frequencies. During the actual measurements, however, the ammeter was removed.

Reference Standards

The selection of a suitable resistance unit for use as a reference standard was an important factor in these measurements. The principal requirements were that the resistance be continuously variable, easily adjusted, and its construction such that when substituted for the test specimen it would not materially change the constants or configuration of the test circuit. These requirements were met by the round wire resistance units shown in Fig. 1 (*A* and *B*). Each type of unit was constructed of 2 sizes of copper wire, one somewhat larger, and the other somewhat smaller in cross section than the test specimens. The type shown at *A*, Fig. 1, was provided with a slider by which the relative lengths of large and small wire could be easily adjusted. The second type consisted of 2 sizes of copper wire joined together, and placed in mercury cups so that sliding the unit either way varied the relative length of the large and small wire. The a-c resistance of straight round wire can be calculated readily from published formula (see Bureau of Standards Circular No. 74). The a-c resistances of the adjustable resistor units were therefore obtained by calculating the resistance of separate lengths of large and small wires measured between the contacts. This result was checked by reference to straight round wire specimens of uniform cross-sectional area, the a-c resistances of which were calculated. The accuracy of the method was found to be approximately one per cent.

Mercury cups were provided by which the test bars and the adjustable resistance unit could be easily interchanged. The resistances of the other connections were made as low as possible by the use of tinfoil between the contacts. The contact resistance, including that of the mercury cups, was approximately one per cent of the total resistance of the circuit. The resistance of the Litzendraht

cable constituted approximately 58 per cent of the total circuit, and the test bar 41 per cent. These percentages varied somewhat, depending upon the frequency and the particular test specimens in circuit.

Test Procedure

The procedure of measurement was, first, to adjust the output of the oscillator and tune the test circuit to resonance with the test specimen in the circuit. The adjustable resistance was then substituted for the test specimen, and, with the output of the oscillator held constant, the resistance was varied until the same conditions of resonance were obtained in the test circuit. Since all other constants of the circuit were the same, the resistance of the variable standard unit was then equal to that of the test specimen, and its value was calculated from the relative lengths of large and small wires, as explained above.

The tests were made on specimens representing a range of width-to-thickness ratios of 1:1 to 20:1, which seemed to cover the values likely to be encountered in practice. The physical dimensions of the specimens and range of test frequencies are listed in Table I. The test specimens consisted of soft drawn copper, approximately 71 in. long, of uniform dimensions. Each specimen was accurately machined to the desired width-to-thickness ratio, and precautions taken to insure sharp square edges.

Table I—Dimensions of Test Bars and Range of Frequencies Used in Measurement of A-C to D-C Resistance Ratios

Test Bar Number	Avg Dimension In. a	Avg Dimension In. b	Avg Area Sq In.	Actual Ratio a/b	Nominal Ratio a/b	Test Frequency Range—kc
1*A*	0.0606	0.0602	0.00365	1.007	1	22–179
2*A*	0.0805	0.0404	0.00325	1.99	2	22–179
3*A*	0.1205	0.0300	0.00362	4.02	4	22–179
4*A*	0.1491	0.0256	0.00382	5.83	6	22–232
5*A*	0.1600	0.0202	0.00323	7.93	8	22–232
1*B*	0.1399	0.0718	0.01004	1.95	2	26– 75
2*B*	0.2706	0.0454	0.01228	5.96	6	26– 75
3*B*	0.2812	0.0357	0.01002	7.88	8	26– 75
1*C*	0.242	0.021	0.00508	11.72	12	45-287
2*C*	0.322	0.021	0.00676	15.31	16	45–179
3*C*	0.403	0.021	0.00846	18.18	20	45–179

All test bars were 71 in. long.

The d-c resistance was obtained by the usual bridge method, special care being given to securing specimens of uniform resistivity. Test specimens having different cross-sectional areas, but the same ratio of width to thickness, were selected so that experimental checks of the theory could be obtained by making measurements at different frequencies to satisfy the conditions of the parameter.

The data obtained from the tests are given in graphical form in Fig. 2, in which the ratios of a-c to d-c resistance are plotted as a function of the parameter. The curves in Fig. 3 show a comparison between the data obtained in these tests and those published by Kennelly, Laws, and Pierce for width-to-thickness ratios of 8 and 16. The curves also show the agreement obtained between tests on specimens of the same width-to-thickness ratios, but of different cross-sectional areas. A very close agreement was obtained with the published data and between specimens of different sizes. It is felt that the consistent results thus obtained speak well for the reliability of the data.

From an inspection of the data given in the previously mentioned paper by H. B. Dwight, it might have been anticipated that, except for the initial curvature near the origin, these curves would be straight lines. Apparently, however, this is by no means the case, although it is approximately true within the limits of the tests in the particular instance of the conductors having width-to-thickness ratios of 1:1 and 2:1. For other width-to-thickness ratios, the curves tend to bend upward for values of parameter above 5.5. The close agreement between the curve for a round wire and the curve for the 2:1 specimen is interesting to note, and also the fact that the skin effect in a square conductor is consistently greater than that of a round wire.

Determination of Skin Effect at Commercial Frequencies

In order to reduce the data to convenient form for determining skin effect at commercial frequencies, Figs. 4 and 5 were prepared. From these curves, the skin effect in rectangular conductors at 60 cycles or 25 cycles can be readily determined. Similar curves for any frequency can be easily calculated from the basic data given in Fig. 2.

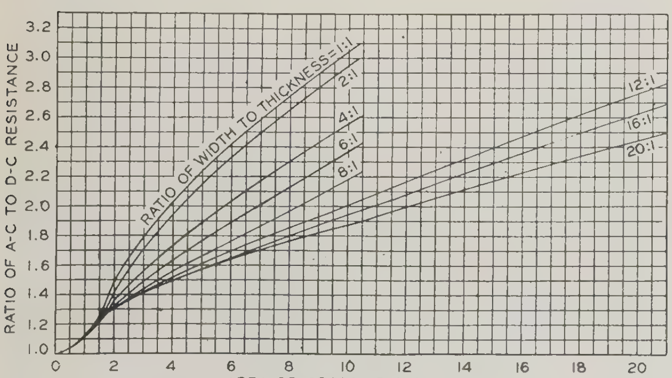


Fig. 4. Skin effect in strap copper conductors at 60 cycles

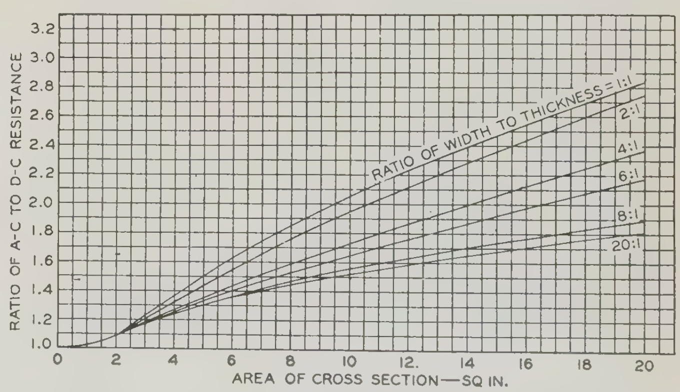


Fig. 5. Skin effect in strap copper conductors at 25 cycles

News

Of Institute and Related Activities

A.I.E.E. Directors Meet at Institute Headquarters

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, N. Y., on August 8, 1933.

Present were: *President*—John B. Whitehead, Baltimore, Md. *Past-presidents*—H. P. Charlesworth, New York, N. Y.; and C. E. Skinner, Wilkinsburg, Pa. *Vice-presidents*—F. M. Craft, Atlanta, Ga.; A. H. Hull, Toronto, Ont.; E. B. Meyer, Newark, N. J.; R. W. Sorensen, Pasadena, Calif.; and A. M. Wilson, Cincinnati, Ohio. *Directors*—L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; P. B. Juhnke, Chicago, Ill.; A. E. Knowlton, New York, N. Y.; G. A. Kositzky, Cleveland, Ohio; Everett S. Lee, Schenectady, N. Y.; A. H. Lovell, Ann Arbor, Mich.; A. C. Stevens, Schenectady, N. Y.; and H. R. Woodrow, Brooklyn, N. Y. *National treasurer*—W. I. Slichter, New York, N. Y. *National secretary*—H. H. Henline, New York, N. Y.

The following resolutions were adopted in memory of F. W. Peek, Jr.

WHEREAS, the death on July 26, 1933, of Frank William Peek, Jr., chief engineer of the Pittsfield Works of the General Electric Company, removed an outstanding leader in electrical engineering practice and research;

WHEREAS, Mr. Peek had been a member of the American Institute of Electrical Engineers for about 26 years, and had rendered splendid services to the engineering profession as well as to the Institute as a member of its board of directors, as chairman and member of numerous committees, and as the author of many technical papers;

WHEREAS, his pleasing personality, his brilliant mind, his wide scientific and engineering knowledge, and his steadfast adherence to the highest ideals had won him a multitude of friends and a high place among engineers in general, and particularly among officers and members of the Institute, be it therefore

RESOLVED: That the board of directors of the American Institute of Electrical Engineers, upon behalf of the membership, hereby expresses its deep sorrow at the death of Mr. Peek; and be it further

RESOLVED: That these resolutions be entered in the minutes of this meeting and transmitted to members of his family.

The minutes of the board of directors meeting of June 28, 1933, were approved.

A report was presented and approved of a meeting of the board of examiners held July 27, 1933. Upon the recommendation of the board of examiners, the following actions were taken on pending applications: 3 applicants were elected and 25 were transferred to the grade of Member; 30 applicants were elected to the grade of Associate; 9 Students were enrolled.

The chairman of the finance committee reported disbursements for the months of July and August amounting to $19,822.55 and $14,813.87, respectively.

The last sentence of Sec. 48 of the by-laws, covering the procedure in payment of appropriations to Sections, was amended to read as follows:

"An accounting shall be made to the finance committee of the Institute, through the national secretary, when these funds have been expended, whereupon a remittance of the balance of the appropriation for that year may be transmitted to the secretary of the Section and similarly accounted for at the expiration of the appropriation year."

Announcement was made of the committee appointments made by the president for the administrative year beginning August 1, 1933, and various representatives were appointed by the board. (The list of committees and representatives is given at the end of the news section in this issue of ELECTRICAL ENGINEERING.)

Upon the recommendation of Mr. Bancroft Gherardi, past chairman of the committee, it was voted that the name of the public policy committee be changed to "Institute Policy Committee."

In accordance with the by-laws of the Edison Medal committee, the board confirmed appointments to the committee made by the president as follows: C. E. Stephens, chairman for the year beginning August 1, 1933; Vannevar Bush, H. P. Charlesworth, and K. S. Wyatt, for terms of 5 years each. Also, the board elected from its own membership to serve for terms of 2 years each: L. W. Chubb, G. A. Kositzky, and H. R. Woodrow.

In accordance with the by-laws of the Lamme Medal committee, the board confirmed the following appointments by the president: C. F. Harding, Malcolm MacLaren, and R. W. Sorensen, for terms of 3 years each; C. E. Skinner reappointed as chairman for the year beginning August 1, 1933.

Professor C. A. Adams was appointed a representative of the Institute upon the council of the American Association for the Advancement of Science, to succeed Mr. F. W. Peek, Jr., deceased.

Local honorary secretaries were reappointed for the 2-year term beginning August 1, 1933, as follows: M. A. Chatelain, for Russia; A. F. Enstrom, for Sweden; A. P. M. Fleming, for Great Britain; Renzo Norsa, for Italy; P. H. Powell, for New Zealand; and F. M. Servos, for Brazil.

Chairman E. B. Meyer of the publication committee presented briefly the plan which was recommended by that committee and discussed at length during the conference of officers, delegates, and members, in Chicago, Ill., under which it is proposed to consolidate the present monthly ELECTRICAL ENGINEERING and quarterly TRANSACTIONS into a single publication to be issued monthly to all members. The board voted its approval of the plan.

The president was empowered to appoint a representative on the advisory board of the National Bureau of Engineering Registration, which has been organized by the National Council of State Boards of Engineering Examiners.

Mr. A. S. Garfield, local honorary secretary of the Institute for France, was appointed a delegate of the Institute to attend the celebration, in Paris, on November 23–26, 1933, of the 50th anniversary of the foundation of the Société Internationale des Electriciens. Mr. A. P. M. Fleming, local honorary secretary for Great Britain, was designated to represent the Institute at a luncheon, on September 15, 1933, in London, in connection with the 12th Shipping, Engineering & Machinery Exhibition.

Other matters were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.

Comments on Engineering Education Requested

The Institute has a continuing interest in educational matters. Periodically this interest is crystallized in the shape of a group of papers as for example in 1892, 1902–3, 1908, 1922 Niagara Falls symposium, 1926, and 1932.

In the present period of rapid social and industrial change, what in the opinion of the A.I.E.E. members should be our educational policies? In the light of the last 4 years what changes if any should be made in our electrical engineering curricula? Is there any individual bold enough to predict how many electrical engineering graduates will be needed in 1937? The Institute committee on education welcomes your comments, which may be addressed to the chairman of the committee, L. A. Doggett, State College, Pa.

Lamme Medal of S.P.E.E. Awarded

Dexter S. Kimball, dean of the college of engineering, Cornell University, Ithaca, N. Y., past-president of The American Society of Mechanical Engineers, and past-president of the Society for the Promotion of Engineering Education, was awarded the Lamme medal of the latter organization during the 41st annual meeting of this society, held at Chicago, Ill., during Engineers' Week, June 25–July 1, 1933.

Two other Lamme medals are awarded each year, one by the A.I.E.E., and the other by the Ohio State University; announcements regarding these other Lamme medals were given in ELECTRICAL ENGINEERING for July 1933, p. 504. Dean Kimball is the sixth recipient of the Lamme medal of the S.P.E.E., which is awarded each year by that society "to a chosen technical teacher for accomplishment in technical teaching or actual advancement of the art of technical training."

Report of National Research Council

In the report of the chairman of the council to the executive board of the National Research Council concerning activities during May and June 1933, a number of items of considerable interest are noted. In the division of engineering and industrial research, the first of a series of regional conferences planned for the discussion of relationships between industry and the universities in matters of research was held in Chicago, Ill. The purpose of these conferences is to bring out information concerning the nature of the research in progress at these institutions which would be of interest to various industries, and the facilities of these institutions which would put them in position for undertaking certain types of industrial research, and also to consider the ways in which industry can avail itself of these research resources and the conditions under which investigations upon industrial problems might be of advantage to these institutions.

The committee on fundamental research in welding has nearly completed a new set of specifications for welding wire which are based upon the actual physical properties of the finished welds. The committee on structural steel welding which completed last year an exhaustive series of tests extending over 5 years upon the types of joints to be used in the welding of structural steel for buildings and bridges has undertaken an additional program for the investigation of methods for testing the strength of these joints.

The division of physical sciences reports that for the coming year 4 new committees have been appointed in that division as follows:

1. A committee on symbols, units, and nomenclature to represent the United States in coöperating with a similar committee of the International Union of Pure and Applied Physics. The division's committee will offer its services in effecting the definition and adoption of physical terms and units by scientific and engineering agencies in this country engaged in standardization.
2. A committee to prepare a bibliography of orthogonal polynomials.
3. A committee on methods of measurement of radiation, particularly spectrally distributed radiation, looking toward the preparation of a monograph on the measurement of radiation.
4. A committee on a service institute for biological physics to consider the feasibility of organizing an agency to facilitate the utilization by biologists of physical radiations of various types needed in the wide range of experimentation now being undertaken upon the effects of these radiations on plant and animal life.

The fifth edition of the list of industrial laboratories in the United States, published by the National Research Council, includes 1,575 laboratories, about 50 less than were given in the previous edition of $2^1/_2$ years ago. These laboratories report a total number of 23,742 scientific employees. The number of scientific employees in the laboratories previously listed was about 36,212. Of the laboratories reporting this year, 643 (about 40.8 per cent) representing 5,461 employees, reported no changes in personnel; 113 laboratories, about 7 per cent of the previous number, employing about 835 scientific men, have been discontinued; 170 laboratories with 1,430 scientific employees have been reported this year for the first time. In 187 laboratories the number of scientific employees was increased since 1930 from 4,437 to 6,219 (a gain of about 40 per cent), but in 512 laboratories (about $^1/_3$ of those reporting) the number of employees was decreased from 25,479 to 10,632 (a loss of about 58.25 per cent); 49 laboratories gave no personnel data in their returns.

The Council has recently been informed that the Rockefeller Foundation has made 2 appropriations to the council for the continuation of support of post-doctorate fellowships for the academic year 1934–35: One appropriation of $150,000 for the series of fellowships in the physical sciences, astronomy, and mathematics and for the series for the biological sciences; and a further appropriation of $30,000 for the support of fellowships in the medical sciences.

Hay Fever and Asthma Victims Relieved by Conditioned Air.—Experiments which have been carried out for some months at The Johns Hopkins University, Baltimore, Md., have indicated the great relief which can be obtained by victims of hay fever and asthma through the use of air conditioning equipment to remove pollen and dust from the air, and cool the air. It was found that complete relief was given to patients suffering from symptoms of hay fever whether they occupied the air conditioned room for several hours or for longer periods of time. Striking relief was given to patients suffering with pollen asthma within 12 hours after admission to the room. It was determined that for individuals who can make provision for such atmosphere, whether in their homes of offices, great relief can be offered.

Welding Pipe Lines in the Oil Fields of Iraq

A PIPE line, 1,180 miles in length, fabricated by the modern electric arc, is being laid through the ancient lands of Iraq, Palestine, and Syria. Above are shown natives of Palestine following the welding crews, marveling at the wonders of the electric arc, and at the side is shown "Crossing the Jordan" 1933 style. These dual 10-in. pipe lines also traverse the famed Tigris and Euphrates rivers. The pipe line taps the rich oil fields of Iraq (formerly called Mesopotamia) and extends from Kirkuk to the Euphrates River, a distance of about 150 miles, from which point a southern leg extends 467 miles to Haifa, a Mediterranean port in Palestine, and a northern leg extends 381 miles across French territory to Tripoli, a port in Syria. The line is being laid by the Mediterranean Pipe Line Company, Ltd., a subsidiary of Iraq Pipe Line Company, Ltd., an international company controlling rich oil deposits. Four welding gangs working at widely separated points find welding complicated by strong winds, dust storms, and rugged country. Despite this, reports from one gang show that 2 welders and a tacker are tying-in as high as 4 miles of pipe in an 8-hr day. Many American welding operators are being employed on the project. Welding is being done with welders and "fleet-weld" electrodes manufactured by The Lincoln Electric Company, Cleveland, Ohio. Mountains and valleys well below sea level are crossed by this pipe line, one point 862 ft below sea level having been reported. The line is scheduled for completion early in 1934 and will have a capacity of 30,000,000 barrels of oil annually.

Business Conditions and Postgraduate Study

The influence which business conditions have on postgraduate study in engineering subjects is discussed in a brief article prepared by Erich Hausmann (A'06, F'18) professor of physics and electrical communication and dean of graduate study, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. Some of the work being done at the Polytechnic Institute of Brooklyn also is mentioned. Doctor Hausmann's remarks follow:

"Will continued industrial activity at a lower level than that of the boom years cause a continuation of the marked increase in graduate study in engineering? This is a question that faces colleges and universities throughout the country, and the answer seems to be in the affirmative, for institutions everywhere report considerable growth in graduate enrollments despite retrenchment and curtailment of graduate fellowship funds.

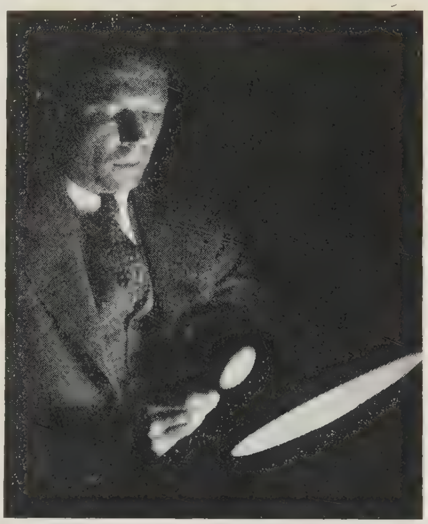
"The active interest in graduate study throughout the country is one of the pronounced trends in engineering education during the last decade. Enrollments in graduate courses increased from about 1,000 in 1921 to more than 3,000 in 1931, and since then the growth has been even more pronounced. Part of this increase has been attributed to the failure of recent graduates to obtain positions immediately after receiving their first degrees. These young men, wishing to maintain the normal rate of intellectual growth of their undergraduate days, have found graduate study the only outlet to their ambitions. They have further recognized a condition that has become apparent in industry, namely, that a distinct premium is being placed upon the additional year or years of study in the graduate school. No doubt, this condition reflects the opinion of executives that men with such training have demonstrated a faster growth in technical achievement and professional responsibility than others with less broadened horizons.

"Institutions situated in different environments have met this demand in different ways. The most common has been through the provision of more full-time graduate courses with a view to building more comprehensive curriculums in advanced subjects. A very interesting variant of the customary method has been through the provision of postgraduate courses on a part-time basis. A number of institutions in urban communities have provided graduate courses in the evening during the past few years. Prominent among these are the Massachusetts Institute of Technology, Union College, Polytechnic Institute of Brooklyn, University of Pittsburgh, University of Pennsylvania, and Columbia University. The Polytechnic Institute of Brooklyn, as an illustration, introduced evening graduate instruction 8 years ago, after 20 years of experience with evening engineering of college grade. It now has 250 graduate students in engineering and chemistry and June 1933 graduated 22 with masters' degrees. Among the 41 courses to be offered during the coming season are the following of interest to electrical engineers: advanced circuit theory, power transmission and distribution theory, electromagnetic theory, electrical protection in power systems, and theory of vacuum tubes and their circuits. In addition there are a number of graduate courses in physics, mathematics, and chemistry.

"This movement in engineering education will be watched carefully by engineers and educators. Apparently the answer to the moot question of the length of the engineering curriculum is being given through this normal evolution toward advanced study leading to higher degrees, rather than through the lengthening of the undergraduate curriculum itself."

Photographs Made With Invisible Rays

A new source of artificial ultra-violet rays may make it possible to take some classes of photographs without the aid of visible light. Experiments in this direction have been made with a Westinghouse ultra-violet



treatment lamp which for this particular purpose has been constructed with a bulb of black glass that filters out nearly all visible light and permits only the transmission of long-wave ultra-violet rays which in the pure state are invisible. These rays are strong in actinic quality, that property of radiant energy which produces the chemical changes on photographic plates so that it is possible to take photographs in the dark.

The photograph reproduced here is stated to have been made with only the ultra-violet radiations emanating from one of these lamps, there having been no other visible light present in the room. The black bulb of the lamp screens out approximately 99 per cent of visible light generated, as noted by the almost complete absence of halations. The exposure required 0.5 sec using a fast press plate and with a lense open stop of *F 4.5*.

Ultra-violet radiations have already been advocated as a means of taking "unseen" photographs in the dark, perhaps in children's nurseries or in banks, making it possible to obtain photographic evidence on intruders or safe crackers. A more plausible possibility, however, is that for portrait work. The high intensity visible illumination necessary in studios creates such brilliancy that subjects often cannot help but squint their eyes and thus twist their faces into unnatural expressions. Under the rays of several black bulb ultra-violet lamps, however, the visible illumination is so nearly negligible that little eye discomfort results. The actinic quality of the ultra-violet rays and the use of suitable plates assures successful proofs.

Annual Safety Congress to Be Held in October. The 22nd annual safety congress of the public utilities section of the National Safety Council, Inc., will be held at Chicago, Ill., October 2–6, 1933, with headquarters at the Stevens Hotel. Among the papers which are scheduled for presentation are 3 on the subject of safety training from the standpoint of the psychologist, the teacher, and the industrial executive. Another feature is a group of 3 papers on the subject of physical plant from the safety standpoint, discussing the responsibility of the design engineer, the construction engineer, and the operating engineer. These last 3 papers will be presented, respectively, by W. R. Smith (M'18, F'30) assistant chief engineer, United Engineers and Constructors, Inc., Newark, N. J.; C. R. Beardsley (A'08, F'30) assistant superintendent of distribution, Brooklyn Edison Company, Brooklyn, N. Y.; W. A. Buchanan, district manager, Appalachian Electric Power Company, Welch, W. Va.

Special Graduate Courses at Columbia University

The department of electrical engineering of Columbia University, New York, N. Y., is endeavoring to cater to electrical engineers who are graduates of any recognized technical school by offering graduate courses in special advanced subjects given between the hours of 4 and 6 p.m. for the special convenience of those employed in the city.

The courses available this fall are operational calculus, filters and networks, and power system analysis. These courses carry credit for the master's and doctor's degrees.

Meeting of Iron and Steel Electrical Engineers. The Association of Iron and Steel Electrical Engineers extends an invitation to every steel mill man, from executive to laborer, and to every person interested in steel mill equipment, to attend the 29th convention and iron and steel exposition which will be held at the William Penn Hotel, Pittsburgh, Pa., October 17–19, 1933. An invitation also is extended to see the latest developments in machinery on display and in operation, and to attend the technical sessions and listen to and take part in the discussions on the various papers to be presented. Additional information may be obtained from the managing director, J. F. Kelly, Empire Building, Pittsburgh, Pa.

Summarized Review of Some Summer Convention Discussions

PRINCIPAL discussions of the first few sessions held during the summer convention were summarized in ELECTRICAL ENGINEERING for August 1933, p. 578–81. Discussions of other sessions are presented herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for June 1933, p. 412–19, excepting the papers given more complete treatment in that issue. Additional articles based upon these papers are being presented in subsequent issues.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion, together with all approved papers, will be published in the TRANSACTIONS.

Communication

CARRIER IN CABLE

C. S. Demarest (New York, N. Y.) in part of his discussion referred to this development as representing the first instance in which consideration had to be given to the use of the relatively high frequencies involved, with such large numbers of equipment units as may be assembled together. Perhaps several hundred such units may be expected in a large cable carrier terminal, as compared with a dozen or so now encountered in a typical open-wire carrier installation. This, he explained, brings increased need for compactness in the carrier apparatus with greater need for shielding between certain parts. It was stated that fairly compact arrangements were provided at Morristown with these needs in view, particularly in the case of the amplifiers, although clearances between units and groups were made very liberal as a convenience in the testing.

Another discusser, G. Ireland (New York, N. Y.) traced some of the history of the development of the carrier current systems for open-wire lines and cited the continual process of improvement and simplification which has occurred. He viewed this new development in the light of experience obtained with the open-wire carrier and predicted that the same history of continued improvement through developments, of application first to existing cable facilities and then of increased application to both existing cable plant and new plant, especially provided for such a system, will take place.

Power Generation

DESIGN FEATURES OF THE PORT WASHINGTON POWER PLANT

J. R. Baker (Baltimore, Md.) in his discussion pointed out the importance of this paper as embodying the best thought in station design, though it originated 4 or 5 years ago. The design of this station shows quite conclusively the value of simplification, which offers the greatest opportunity for reduction in investment cost. With the improvement which has been made in the reliability of both steam generating and turbine equipment in the last few years, the single unit type of station is rapidly gaining favor.

H. E. Christie (Baltimore, Md.) was impressed on first reading the paper with the painstaking consideration given to all equipment and particularly by the complete dollar analysis applied to each decision. He believed this was good engineering for little should be left to pure opinion or personal preferences unless these are actually justified by the economics of the case. He inquired as to the basis for the selection of 60 per cent annual load factor. This assumption was questioned for in the past the average load factors of station equipment over their whole useful life falls greatly below this figure.

I. E. Moultrop (Boston, Mass.) in his discussion of this paper paid tribute to the pioneering spirit of the company with which the author is associated. He felt that the design described in the paper again points out the results that can be obtained by careful engineering study and intelligent economic analysis. One of the features with which the discusser was not in agreement was in regard to the comparative merits of the unit system of pulverized coal firing in comparison with the bin system. In view of the results being obtained in many stations with the unit system of pulverized coal firing the accuracy of the statement that in commercial operation the bin system will show 2.1 per cent better station economy than the unit system was especially questioned, and it was the discusser's belief that this statement could not be substantiated.

Another discusser, R. C. Powell (San Francisco, Calif.) compared data given in the paper with their experiences from the operation of station *A* and studies on the design for the proposed plant for the San Joaquin Light and Power Corporation at Herndon. These studies confirm in general the conclusions arrived at by the author, namely, that a single boiler and turbine installation operating at 1,250 lb pressure and 850 deg F maximum temperatures for primary superheat and reheat is the best economically, all things considered, and is as reliable as low pressures and temperatures. In regard to the author's statement about inconvenience in operation and maintenance for the vertical compound unit the discusser stated that this was not confirmed by the experience at station *A* after $2^1/_2$ years' operation with the type where the high pressure units are mounted on the low pressure generator. So far as can be determined to date, such units have neither operating nor maintenance disadvantages.

Philip Sporn (New York, N. Y.) in his discussion of the paper considered several of the electrical design features. In connection with the splitting of the auxiliary load into 3 groups, namely, 2,300 volts alternating current, 480 volts alternating current and direct current, and drawing a line of demarcation between the 2 a-c voltages at approximately 100 hp, he inquired whether a voltage of 550 volts was considered and, if so, what the reasons were against its adaptation. He pointed out that most low voltage switching equipment in the 480-volt range permits safe operation at 550 volts; furthermore, with the newer oil-less switching equipment the economic limit of the lower voltage would be closer to 250 hp than 100 hp. This would permit a considerable saving by the elimination of the 2,300-volt switching equipment.

IMPROVEMENTS AT BURLINGTON GENERATING STATION

T. E. Purcell (Pittsburgh, Pa.) commented on this paper as presenting an excellent illustration of how intelligent engineering can apply modern power developments toward the economical use of older plants. The physical arrangement of the plant presented some ideas which he believed had not been commonly used heretofore. He thought the arrangement of the raw coal bunker and coal preparation plant at a low elevation at one side of the boiler room is good. However, the reason for locating the boiler room substation underneath the boiler could not readily be determined from the paper. The discusser believed that placing this substation in some other location, lowering the boiler, and reducing the height of the building might have saved considerable of the cost.

BEAUHARNOIS DEVELOPMENT OF THE ST. LAWRENCE RIVER

B. L. Barnes (Peterboro, Ontario, Can.) described in detail some of the design features of the generator units. He also told of the special architectural considerations of the generator frames and covers which were devoted to obtaining the desired effect of balance proportions, size, and pleasing appearance.

J. R. Dunbar (Hamilton, Ontario, Can.) commented on one of the most striking innovations in the powerhouse, namely, the use of the umbrella type construction for the large generators with the thrust bearing below the generator rotor. He described the generator installation in the Ruskin development of the Western Power Company of Canada, the construction of which was very similar to that used for the Beauharnois generators. In both cases there is no heavy bracket upon the generator stator and the only structure there is a light covering.

J. G. Glassco (Winnipeg, Manitoba, Can.) in his discussion drew attention to the simplicity of the general layout and the apparent lack of complicated operating arrangements in spite of the enormous amount of energy to be handled. In regard to the use of brick the discusser was curious to know what method was used to take care of the contraction problem at the point where the brick superstructure bridges over the contraction joints in the concrete substructure.

N. E. Funk (Philadelphia, Pa.) discussed several of the important features in the paper. Excepting the size of the future development he believed the most impressive features are those of the basic design of the power canal, the tail races, and the switching areas. These features provide

for the ultimate installation without placing an undue construction cost burden upon the initial development and further permit the addition of the future plant extensions with practically no construction nor any interference with operation.

N. B. Higgins (Baltimore, Md.) commented upon the author's statement that the total ultimate capital investment will be as low as if the ultimate installation had been constructed in one operation. He was of the opinion that this statement stressed one of the most unique features of the project, namely, its easy adaptability to growth step by step, particularly to the increasing load. For the project of the size of Beauharnois this coördination of installation cost and power demand he considered as important.

Electrophysics and Related Subjects

Polarity Factor in the Kindling of Electric Impulse Sparkover

F. O. McMillan (Corvallis, Ore.) in his discussion of this subject called attention to a very important electrode not mentioned in the author's list of those producing unsymmetrical dielectric fields. He bebelieved attention should be directed to the use of 2 spheres of the same size with one sphere grounded for measuring alternating and impulse voltages. He explained that the importance of considering this electrode combination is shown by the fact that practically all high voltage laboratories employ grounded circuits for both alternating and impulse voltage tests and use grounded sphere gaps extensively for making high voltage measurements.

Controlled Radiation From Electrically Heated Walls

R. E. Hellmund (E. Pittsburgh, Pa.) discussed this subject from the standpoint of conveying the fundamental ideas to the average engineer. He believed that unquestionably engineers will find it easiest to understand the fundamentals entering into human comfort by considering the analogy between the human machine and the electrical machine as well as certain differences that exist between the 2. The principal difference to be considered is that the human organism under normal conditions maintains a more or less constant temperature regardless of surroundings. The author analyzed conditions that obtain and with the aid of 4 figures applied them in connection with several assumptions. The important part played by convection was fully explained.

D. R. Teare (Schenectady, N. Y.) discussed the comfort criterion proposed by the author and the possible power savings obtainable through the panel heating. In connection with discussion of the comfort criterion a problem assigned several months ago to the thermal engineering section of the advanced course in engineering of the General Electric Company was used as an illustration. The results of the analysis, which were given in a curve sheet, led to the belief that it may be safer to place reliance in experimental criterions of comfort rather than in calculations based on questionable assumptions. In regard to panel heating the discusser pointed out that where radiant panels are installed in external walls, as they should be, to counteract radiation from the body to those cold surfaces, the conduction loss through those wall sections tends to increase. The discusser did not see justification for the author's claim that panel heating promises lower operating costs than other methods of electric heating.

Probe Measurements and Potential Distribution in Copper A-C Arcs

J. Slepian (E. Pittsburgh, Pa.) made the following comments in his discussion of this subject. This new application of the cathode ray oscillograph to the study of the potentials of probes in an a-c arc has led to interesting and valuable results. It shows quite definitely for short metallic arcs the development of the voltage bearing larger next to the cathode during the transition period. While this had been surmised before, it is very gratifying to see here a direct experimental confirmation of this important phenomenon.

Theory of Primary Networks

L. M. Olmsted (E. Pittsburgh, Pa.) compared the results of an extensive calculating board analysis of a network which differed only from the author's in that it included 4 more transformers located one at each corner of the network, and omitted the long ties shown in Fig. 2 of the paper. The methods of analysis were too dissimilar to permit direct comparison for interlaced transmission but parallel transmission was handled in an exactly identical manner. As a result of this comparison, the discusser concluded that the paper does not show the worst loadings for parallel transmission, even for the network constants upon which it would seem to be based. It did not seem to him to be practical to install tie circuits of from 3 to 6 times the length of the ties between adjacent transformers to have the same short impedances as the shorter connections. It seemed more practical to eliminate entirely the tie circuits outside the square network and in their place install 4 more transformers, one at each corner of the mesh. The discusser believed that this change entails little, if any, increase in system investment, provides more satisfactory operating characteristics, and can be so loaded as to increase the load capacity of the entire network.

In connection with this subject, M. S. Schneider (Cincinnati, Ohio) described the 208/120-volt a-c network system installed at Cincinnati, and he told of a problem that developed in a low voltage network using induction voltage regulators. He believed that the problem also applies to primary networks using automatically-

Field Fabricating Plant at Boulder Dam

Babcock and Wilcox Photo

FABRICATION of the pipe for Boulder Dam must be performed at the site of the dam because the finished pipe sections are too large to be transported by railroad. Here is shown an interior view of the 520 x 90-ft field fabricating plant, which is fully equipped to fabricate by fusion welding, and to test by X ray, 14,500 ft of pipe $8^1/_2$ to 30 ft in diameter from steel plate ranging in thickness from $^7/_8$ in. to $2^3/_4$ in. Pictured here is the fabrication of steel pipe $8^1/_2$ ft in diameter from plates $^7/_8$ and 1 in. in thickness. Approximately 400,000 linear ft of welding will be performed in the fabrication of all sizes of pipe. Automatic fusion-welding machines are shown at the left. In the right foreground may be seen part of the indexing and drill-support mechanism for drilling girth seams in pipe sections 25 ft and 30 ft in diameter. Some of these larger pipe sections will weigh about 150 tons.

controlled tap-changing transformers by means of which voltage is maintained constant at the load center.

Electrical Machinery

Transient Torques in Synchronous Machines

R. Baudry (E. Pittsburgh, Pa.) in his discussion of this subject presented a calculation of the mechanical torques in the shafts of a tandem compound turbine-generator, where the rotating element is composed of 3 masses connected by 2 shafts. In this case the problem is more complicated than the cases in the paper and the mechanical and electrical decrements can be neglected in order to simplify the solution. The mechanical torques thus calculated are slightly larger so the calculation is on the safe side. It was explained that this calculation was made in collaboration with the authors since the paper had been written.

Another discusser, J. F. Calvert (E. Pittsburgh, Pa.) outlined the authors' achievements and the value of the paper as follows: It is a much needed contribution to an important problem in the design of large a-c machines. The discussion of the electrical loss torques is probably the first serious study of this problem which has been published. These loss torques are shown to be of at least equal importance with the alternating ones so far as the rotor couplings are concerned. The discusser also pointed out that the studies given to torques due to synchronizing out of phase, and to those due to falling out of step, are also new and equally valuable contributions. In addition, a short discussion of the derivation of formulas for electrical torques was given to show a physical picture of the problem.

I. A. Terry (Schenectady, N. Y.) clearly pointed out the practical application of the authors' analysis which concerns construction and operating companies, as well as the manufacturers. He explained that it is necessary to design rotating machinery so that the stresses set up during electrical disturbances do not produce permanent deformation of parts. Furthermore, it is necessary to have the foundation design ample to withstand the forces to which the foundation is subjected. Since the cost of the foundation is an item of considerable magnitude in any installation, it is not possible to make an economical design without a fairly accurate knowledge of the forces involved under all conditions of operation which may occur.

Improvements in Mercury Arc Rectifiers

R. E. Hellmund (E. Pittsburgh, Pa.) in his discussion gave consideration to the future for mercury arc rectifier applications. He explained that not only is the rectifier now the proper device for ordinary rectification in many cases where it previously could not compete with synchronous converters and motor generator sets, but such applications as the regulation of induction motors with a rectifier in the secondary, and many other possibilities previously suggested, are coming closer to a practical and economical realization. It seemed to the discusser that the promising field of application for many electronic devices might be limited to smaller amounts of power, certain control problems, and some special applications. On the other hand it seemed that the future of the pool-cathode mercury arc devices is becoming brighter every day, as the basic factors entering into their design and operation are becoming better understood.

Current and Voltage Wave Shape of Mercury Arc Rectifiers

P. W. Blye (New York, N. Y.) discussed this subject from the standpoint of the inductive coördination problem with exposed telephone circuits. He explained that the increasing use of the rectifier in connection with d-c railway systems and its further application in high-powered radio broadcasting stations have made these problems of increasing importance to the telephone companies.

H. Winograd (Milwaukee, Wis.) discussed this subject and compared eqs 2, 5, and 6 in the paper with the corresponding equations on p. 90 and 91 of the book "Mercury Arc Power Rectifiers." He pointed out that the equations in the paper and the corresponding equations in the book give identical results. It was explained that the apparent discrepancy is due to the fact that the equations in the book were derived using the point of intersection of 2 consecutive sine waves as the reference point while in the paper the maximum point of the sine wave was used as the reference point.

H. E. Kent (New York, N. Y.) in his discussion of this subject described a problem of noise induction in communication circuits encountered in connection with a mercury arc rectifier installation. The discussion brought out that wave shape distortion is not reduced appreciably in transformation from one voltage to another. The discusser also explained that there have been cases where the wave shape distortion on the distribution circuits has been considerably more important than that on the transmission circuit feeding the rectifier. This was because the distribution citcuits had a greater coupling with the telephone circuits as a result of joint construction and because they involved a considerably larger amount of exposure with telephone circuits than was the case with the transmission circuit.

Effect of Protective Devices on Stresses in Transformers

C. S. Sprague (Lafayette, Ind.) in discussing the paper on "The Effect of Transient Voltage Protective Devices on Stresses in Power Transformers," agreed with the authors in that the rod gap, or possibly a specially designed bushing or gap in the case of small transformers, should be used as a last line of defense in conjunction with suitable arresters. In connection with the reduction of internal stresses by the use of wave modifiers or internal shielding, which is usually expressed relative to the stresses produced by a steep front wave, the discusser pointed out that it should be remembered that in practice the large majority of waves which reach the transformer will have suffered attenuation. Therefore, the actual reduction in turn stresses due to the protective equipment may not be as large as anticipated.

K. B. McEachron (Pittsfield, Mass.) presented some data concerning the operation of some of the protective devices mentioned in the paper when these are applied to distribution transformers. He explained that the use of some sort of wave modifier to decrease the steepness of the wave front is commonly supposed to be the only protective method which does not involve structural changes in the transformer itself. Further consideration will show that a reduction of amplitude might accomplish the same purpose; for example, if the amplitude is reduced to zero, obviously the turn stresses will be zero, similarly the rate of rise also will be zero. To illustrate this feature of arrester protection, the discusser summarized some tests recently made in Pittsfield, in which the wave modifier of the type described by the authors on p. 6 of the paper was employed.

Another discusser, V. M. Montsinger (Pittsfield, Mass.) considered the protection of wave modifiers, themselves, against lightning and also the proper insulation level for a protective device of this kind. He explained that, unless these modifiers have a substantially higher level of insulation than the transformer being protected, it is a case of where the protecting device requires the same degree of protection as the apparatus it is protecting. The claim might be made that these modifiers slope the wave front and thereby protect themselves. However, this is not possible because only the wave leaving the modifier is affected by its capacitance.

D. W. Roper (Chicago, Ill.) reported that out of 5,700 distribution transformers installed with the interconnection between the lightning arrester ground and the transformer secondary neutral, only about $^1/_7$ of 1 per cent had failed. When the ages of the transformers that failed are taken into consideration, the results appear to indicate that, with the use of modern types of transformers which are built to withstand a transient voltage test, the present scheme of lightning protection used in Chicago would be practically perfect. Therefore, additional protective measures would not be economically justified. The discusser also commented on the term "lightning arrester," which he believed was a misnomer and in his opnion the term "lightning diverter" would appear to be far more appropriate. He felt that the approval by the A.I.E.E. of the continued use of the present term leaves the field open to name other devices in a misleading manner foreign to their properties.

F. J. Vogel (Sharon, Pa.) in his discussion of this subject considered the voltage stresses that would result across the first duct of both the shell type and core type transformers when various methods of protection are employed, such as coördinating gaps, lightning arresters, and surge absorbers. In the case of the shell type transformer the discussion showed that, in order to obtain the same degree of protection with a surge absorber as that obtained by using a lightning arrester, a sloping of the wave front of from 8 to 12 microsec would be required. In the case of core type transformers, deductions made from the data indicated that about the same degree of sloping of the wave

front would be required. From what data is available the discusser concluded that the maximum sloping to be expected from available surge absorbers is probably from 2 to 4 microsec. Therefore, the discusser believed that such surge absorbers cannot furnish protection to the transformer coil insulation as compared to the modern arrester.

Another discusser, J. M. Thomson (Toronto, Ontario, Can.) related that investigations and experience have indicated that the turn stresses, which normally cause the vast majority of transformer failures from lightning and switching surges, can be reduced to safe limits by a wave modifier without excessive cost, except possibly for the higher voltages. He explained that over 3,000 wave modifiers have been placed in service and many of them have been installed to replace other forms of protective equipment which had failed to give protection. Only 1 or 2 instances of failure in the absorbers themselves have occurred and there have been no failures from lightning in any transformer winding protected by this device. It was further explained that standard design practice calls for sizes of the wave modifiers even larger than those indicated by the authors. This explains why a wave modifier, to give complete transformer protection, cannot under present conditions compete on a price basis with any of the various forms of discharge arrester, except in the lower voltages. Consequently their use is justified only where exceptional protection is required.

Electric Welding

Arc Stability With D-C Welding Generators

E. C. Easton (Bethlehem, Pa.) in his discussion of this subject stated that the authors have presented an interesting method of determining the stability of arc welding generators. He believes that for any welding currents and short arcs, B can be taken as zero throughout the paper. With low currents or arcs which may be stretched considerably, B must be determined from the circuit characteristic and a reliable expression for the arc characteristic. Unfortunately at present there are no adequate data available for the determination of the latter.

Another discusser, B. Lucas (Bethlehem, Pa.) believed that the statement in this paper that the oscillations do not appreciably influence the stability of the arc is true only when the inductance of the circuit is large enough to reduce the size or amplitude of the pulsations to a value less than the current value. This was believed evident from the work in Professor Creedy's paper "Forces of Electric Origin in the Iron Arc" (see A.I.E.E. Trans., v. 51, 1932, p. 556–63).

Traffic Engineers to Meet. Traffic engineers and those interested in traffic engineering problems are invited to attend the annual meeting of the Institute of Traffic Engineers, October 3–6, 1933, at the Stevens Hotel, Chicago, Ill. This annual meeting is being held concurrently with the meetings of the street and highway section of the National Safety Council, also convening at the Stevens Hotel. The program calls for varied talks and discussions on problems relating to the traffic engineering field. Further information regarding the convention may be obtained by addressing the secretary, Hawley S. Simpson, 175 Fifth Avenue, New York, N. Y.

Current Transformer Testing Equipment

Current transformers used for metering must not only have high accuracy, but the error in ratio and in phase angle must be known. The U.S. Bureau of Standards published as research paper No. 580 in the July 1933 number of its Journal of Research, a detailed description of the equipment and methods which it has developed during the past 20 years for making tests of this kind with the highest accuracy, up to currents of 12,000 amp.

This description should be a useful guide to workers in the standardizing laboratories of the large power companies and manufacturers who are called upon to make similar tests, and should also serve to give the metermen who send their transformers to Washington for test a more definite picture of just what procedure is applied to their apparatus.

S.P.E.E. Elects Officers. At the 41st annual meeting of the Society for the Promotion of Engineering Education, held at Chicago, Ill., during Engineers' Week, June 25–July 1, 1933, W. E. Wickenden (A'07, M'13), president, Case School of Applied Science, Cleveland, Ohio, was elected president of the society for the year 1933–1934. The 2 vice-presidents elected were F. V. Larkin, director of mechanical engineering and industrial engineering, Lehigh University, Bethlehem, Pa.; and B. M. Brigman, dean, Speed Scientific School, University of Louisville, Ky. F. L. Bishop, of the University of Pittsburgh, Pa., and W. O. Wiley, of John Wiley & Sons, New York, N. Y., were elected secretary and treasurer, respectively. Members of the council elected were as follows: K. T. Compton, (F'31), president, Massachusetts Institute of Technology, Boston; B. R. Van Leer, dean of engineering, University of Florida, Gainesville; F. E. Ayars, dean, college of engineering and commerce, University of Akron, Ohio; J. B. Finnigan, Armour Institute of Technology; Chicago, Ill.; C. H. Willis (A'22, M'28); Princeton University, Princeton, N. J.; W. N. Gladson (A'92, M'02), dean, college of engineering, University of Arkansas, Fayetteville; and H. B. Walker, University of California, Berkeley.

International Conference on High Voltage Networks. The 7th session of the International Conference of Large High Voltage Electrical Networks was held in Paris, France, during June 1933. The 751 members of the session came from 31 different countries. The number of reports presented totalled 129; among the countries which presented the greatest number of reports were Germany with 23 reports, France with 22, Switzerland with 12, Belgium with 11, and Russia with 11. It is stated that the complete report of the works will be published late in 1933 in 3 volumes in the neighborhood of 2,400 pages, and will contain all reports and discussions. Requests for information on this report should be addressed to the secretary general of the Conference Internationale des Grands Reseaux Electriques A Haute Tension, Avenue Marceau 54, Paris, France.

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. Electrical Engineering will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely.

STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

Line Oscillations—"Tuned Power Lines"

To the Editor:

If an electric impulse is sent into a transmission line it travels at a speed slightly less than that of light. If at the end of the line the impulse is reflected it returns with the same speed. If, at the moment the impulse arrives at the starting point, a second impulse of opposite polarity is sent into the line, the return of the first impulse increases the second impulse, the reflecton of this second impulse increases the third, and so on. That is, if alternating impulses succeed each other at intervals equal to the time required by a wave to travel down the line and back, the effect of the successive impulses is cumulative. In other words, in free oscillation or resonance condition the length of the line is one-half wave length. (See "Tuned Power Lines," by H. H. Skilling, Electrical Engineering, August 1931, p. 634–7; or Trans. A.I.E.E. v. 51, 1932, p. 51–4.)

I have made some tests to determine if it were possible actually to put an electric line into oscillation. I maintained oscillations on an iron telephone line, 101 km long between Torino and Borgosesia, Italy. The 2 wires were operated in parallel with ground return, and the line was fed by an alternator which gave a frequency variable

from 600 to 1,200 cycles per second. Alternator harmonics were removed by a circuit equivalent to a filter.

A single good point of resonance appeared at 940 cycles per second, with the line free from ground at the far end. The amplitude of oscillation dropped to $^1/_5$.

I also tested the line with the 2 wires in series, short-circuited at the far end. This was equivalent to a short-circuited transmission line. The line frequency dropped from 940 to 890 cycles per second when the line oscillated in a halfwave.

Very truly yours,
MARIO MARRO
(Via Valperga Caluso, 24, Torino, Italy)

Engineering Schools and the Changed Conditions

To the Editor:

I am in hearty agreement with the conclusions reached by Professor Karapetoff in his address presented at the A.I.E.E. North Eastern District meeting, Schenectady, N. Y., May 10, 1933, as to the future of engineering education and of the engineering student particularly when he is ready to seek employment. [ED. NOTE: An article containing the substance of Professor Karapetoff's address appears elsewhere in this issue.] The very rapid growth in the development and applications of science which has occurred during the past 25 years is not likely to be repeated in the immediate future. With the restriction of immigration, the fact that the most accessible of the country's resources have already been developed, and the fact that scientific development already supplies all reasonable comforts and many luxuries, it seems reasonable to suppose that the country has reached the normal condition of a steady, but gradual, growth. More over, the day of the single inventor in the attic is a thing of the past; inventions for the most part must be conducted by organizations having large resources and experts in many diversified fields of science. Hence, opportunities for young engineers of only average ability are certain to be much more limited in the future than in the past. As Professor Karapetoff states, the student of mediocre ability will not be given the choice of several positions by the different representatives of industry who in the past have visisted our engineering schools each year. Undoubtedly only a few of the outstanding students will be offered employment by them. This, I believe, makes it incumbent on engineering teachers to encourage outstanding students, to give them opportunities to develop themselves in the highest degree, and not to retard them by a rigid curriculum or by having their progress determined by the abilities of the average student.

In the Harvard Engineering School, we have attempted to meet in 3 ways the conditions outlined by Professor Karapetoff. The fixed curriculum has been abandoned; reading periods have been established; students are urged and encouraged to devote 5 or even more years to their engineering training.

In eliminating the rigid curriculum, we have abandoned the notion that has persisted for so many years in engineering education, that to develop into a successful engineer the student must have devoted so many semester hours to this or that subject, the excellence of his training being determined by the relative proportions of these various subjects.

At Harvard, the student practically arranges his own program. To be awarded the degree he must do satisfactory work in that program. The program must be arranged with a definite purpose and ordinarily must include 2 professional courses in his chosen field. This system has many advantages. In order to arrange his own program of study, the student is compelled to analyze his own abilities and his probable future interests and then must decide on the subjects that will best meet his plans. He naturally must confer at length with his advisers. Such conferences are beneficial to the student in that he discloses his ambitions and at the same time gains a more intimate knowledge of conditions he will meet after graduation. Also, a student is far more interested in subjects that he himself has selected than in courses he is forced to take under a fixed curriculum. Another happy result is that it compels the professors to make their courses worth while. Students have an uncanny ability to appraise courses at their real value and interest in courses having little merit is certain to diminish.

The objection may be raised that students will choose only easy courses. However, this is safeguarded by requiring the program to have a definite purpose, to be well coordinated, and incidentally to be approved by the administrative board of the engineering school. A year's experience has shown that many students in their enthusiasm select a program with more highly advanced courses than they can carry effectively.

The reading period, of approximately 3-weeks' duration, at the conclusion of each semester, is not intended as a review period, but rather as a time of future progress in which, with the background of the course, the student is placed wholly on his own resources. Ordinarily, in addition to a moderate number of problems, a definite report is assigned on a project requiring the use of references to special books and technical journals. The student is obliged to use the libraries and to assimilate material from many sources. In reality the student during this period must educate himself. He may confer with members of the instructing staff if he wishes to discuss matters not clear to him.

It is realized generally that today the standard 4-year course is too short for the effective training of engineers. The complexity of modern engineering makes it difficult in the short time available for the student to master the necessary fundamentals even moderately well. The crowded technical program tends to make him somewhat narrow and lacking in other interests. To meet this situation, the entering students who elect engineering are urged to enter the college and obtain there the arts or science degree before registering in the engineering school. By a proper choice of courses in mathematics and science in the college, it is possible to obtain the Master's degree in engineering in 1 year, or better in 2 years after graduation from college. This plan gives the student a broader and more liberal background for the intensive engineering training which he obtains as a graduate student. Moreover, it gives the student a contact with other branches of learning and thus enables him to judge better whether or not engineering is his outstanding interest.

I should like to know Professor Karapetoff's opinion as to the relative advantages of the standard 4-year course in engineering under present-day conditions and a course of 1 year, or better, 2 years longer, these extra years being devoted to graduate study.

Very truly yours,
CHESTER L. DAWES (M'15)
(Associate Prof. of Elec. Engg., Harvard Univ., Cambridge, Mass.)

Note on Symmetrical Components

To the Editor:

The usual approach to the theory of symmetrical components introduces the subject from a semi-intuitional point of view which inadvertently gives the idea that the discovery of these possibilities was a matter of great good fortune. The object of this note is to show that the resolution of unbalanced polyphase vectors into balanced polyphase systems is a straightforward and natural consequence of a routine *transformation of coördinates.* The ingenuity of L. G. Stokvis' original concept does not, therefore, lie in showing the *possibility* of symmetrical components, but in making a selection of coördinates of such universal usefulness.

In the following equations the transformation is carried out in detail for n phases. Incidentally, from this point of view C. L. Fortescue's first designation "symmetrical coördinates" is seen to be a much more appropriate title than our present terminology "symmetrical components." The general analysis also shows that the terms "negative," "positive" and "zero" sequence are not universally appropriate, being restricted to 3 phase systems by virtue of a coincidence.

A symmetrical polyphase system of n-phases may be represented by the sequence (k integer)

$$E_k,\ a^kE_k,\ a^{2k}E_k,\ \ldots\ldots,\ a^{(n-1)k}E_k \tag{1}$$

where

$$a = \epsilon^{j\frac{2\pi}{n}} = \cos\frac{2\pi}{n} + j\sin\frac{2\pi}{n} \tag{2}$$

Then since $a^{nk} = 1$ the sum of the members of eq 1 is

$$1 + a^k + a^{2k} + \ldots. + a^{(n-1)k} = \frac{1 - a^{nk}}{1 - a} = 0 \tag{3}$$

Consequently there are as many possible symmetrical polyphase systems of n-phases as there are non-redundant sequences of the type given by eq 1. Now if $k = r \pm sn$, where both r and s are integers, and $0 \leq r \leq (n-1)$, then

$$a^k = a^r a^{\pm sn} = a^r \tag{4}$$

so that for values of $k > (n-1)$ the sequence eq 1 repeats some previous value. Therefore, there are $(n-1)$ possible unique and independent symmetrical polyphase systems of n-phases having different sequences.

Let $(E_1', E_2', \ldots., E_n')$ be a system of n vectors. Then it is always possible by an appropriate transformation of coördinates to express these n vectors in terms of any other n complex numbers through the agency of a system of n simultaneous linear equations having constant coefficients. Thus the following system of equations completely defines a new system of vectors $(E_1, E_2, \ldots, E_n)$ in terms of the given system $(E_1', E_2', \ldots, E_n')$ and the *arbitrary* coefficients a:

$$\left.\begin{array}{l} E_1' = a_{11}E_1 + a_{12}E_2 + \ldots. + a_{1n}E_n \\ E_2' = a_{21}E_1 + a_{22}E_2 + \ldots. + a_{2n}E_n \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ E_n' = a_{n1}E_1 + a_{n2}E_2 + \ldots. + a_{nn}E_n \end{array}\right\} \tag{5}$$

Since the a coefficients are entirely arbitrary, they may be chosen so that eq 5 involves only symmetrical polyphase sequences of the type of eq 1; that is

$$\left.\begin{array}{l} E_1' = E_1 + \ldots.. + E_k + \ldots.. + E_n \\ E_2' = aE_1 + \ldots.. + a^kE_k + \ldots. + a^nE_n \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ E_n' = a^{(n-1)}E_1 + \ldots.. \\ \qquad + a^{k(n-1)}E_k + \ldots.. + a^{n(n-1)}E_n \end{array}\right\} \tag{6}$$

The symmetrical components E_k may then be determined upon multiplying each row of eq 6 by the reciprocal of the coefficient of E_k in that row, so that eq 6 becomes

$$\left.\begin{aligned} E_1' &= E_1 + \ldots + E_k + \ldots + E_n \\ a^{-k}E_2' &= a^{(1-k)}E_1 + \ldots \\ &\qquad + E_k + \ldots + a^{(n-k)}E_n \\ &\ldots\ldots\ldots\ldots\ldots\ldots \\ a^{-k(n-1)}E_n' &= a^{(n-1)(1-k)}E_1 + \ldots \\ &\qquad + E_k + \ldots + a^{(n-1)(n-k)}E_n \end{aligned}\right\} \quad (7)$$

Adding the rows of eq 7 and making use of eq 3 and eq 4

$$\begin{aligned} E_k &= \frac{E_1' + a^{-k}E_2' + \ldots + a^{-k(n-1)}E_n'}{n} \qquad (8) \\ &= \frac{E_1' + a^{(n-k)}E_2' + \ldots + a^{(n-k)(n-1)}E_n'}{n} \end{aligned}$$

which equation specifies the transformation of coördinates from the given system of vectors to that of the symmetrical components.

For example, in the case of the familiar 3-phase system of phase voltages $E_1' = E_a$, $E_2' = E_b$, $E_3' = E_c$ eq 8 yields

$$\left.\begin{aligned} E_1 &= \frac{E_a + a^2 E_b + a^4 E_c}{3} \\ &= \frac{E_a + a^2 E_b + a E_c}{3} \\ E_2 &= \frac{E_a + a E_b + a^2 E_c}{3} \\ E_3 &= \frac{E_a + E_b + E_c}{3} \end{aligned}\right\} \quad (9)$$

and from eq 6 it is evident that, in conventional nomenclature,

$(E_1, a\ E_1, a^2 E_1)$ = *negative sequence*
$(E_2, a^2 E_2, a^4 E_2)$ = *positive sequence*
$(E_3, a^3 E_3, a^6 E_3)$ = *zero sequence*

From eq 6 it is also seen that the terminology "positive" and "negative" sequence is permissible only in the case of a 3-phase system, and only then on account of a coincidence.

Very truly yours,
L. V. Bewley (A'27)
(Power Transformer Dept.,
General Electric Company,
Pittsfield, Mass.)

Speculation, or Sound Prosperity?

To the Editor:

When the relation of the prices of commodities to the prices of wealth producing properties and stocks is such that it pays to operate these properties, investment values are sound and the economic system is self-sustaining. Marketing and exchange of capital goods are essential, but on the pretense of being investors the speculators come in and pay high prices for stocks and wealth producing properties, not because they feel that these high prices are justified in terms of long range earnings, but because they expect that somebody else will come along and pay more than they paid for them.

This process yields large profits to an ever increasing number of speculators. These unearned incomes translate themselves into a temporary greater demand for goods. This unsound increased demand for goods raises the commodity price level. This economically unsustainable commodity price level, for a while, yields higher earnings to the owners of wealth producing properties and stocks. These unsustainable higher earnings appear to justify the inflated valuation of wealth producing properties and stocks, which engenders more and more speculation in these lines.

Banks, insurance companies and other financial institutions, necessarily must invest the funds entrusted to them and they do so in what appears to be sound investment, but actually these investments are sunk into inflated properties or securities.

On the one hand many actually sincere investors buy stocks or property, or engage in some business enterprise, or expand their production plans, all of which on account of the speculation boom appear to be profitable but eventually cannot be profitable.

On the other hand the higher prices of capital goods lure many owners to sell their holdings. Indeed many of these owners have been among the most successful operators of our means of production. Some of them retire into an unproductive existence, living on the money thus accumulated, or worse yet, some of them engage in speculation in wealth producing properties and stocks.

Some day when we grow more intelligent or should I say when we grow more honest, or both, we will stop speculation in capital goods. Speculation and unsound financing in the means of production always tend to raise capitalization and contingent indebtedness to the point where it does not pay to operate these means of production.

We have been trying to get out of such predicaments in a number of ways. For instance, the engineers and inventors have been continually raising the efficiency of industry so as to make things pay, which in itself is a good thing. Workers have been working (when they can get work) at routine monotonous jobs for maximum production, in order that industry could afford their hire. Smaller businesses have been and are being driven out of existence. Industry as a whole has been obliged to go into mass production in order to make things pay. With all this has the problem been solved? No. Because as the means of production are made more efficient there is that much more speculation absorbing all the benefits thereof. The inevitable climax is overproduction, paralyzed industry, unsound financial conditions, and unemployment.

The currency inflation or decrease of the gold content of the dollar, aimed to raise the prices of commodities to the point where it will pay to operate the means of production, will sooner or later be taken advantage of by the speculating element who will come in again, buying and selling stocks and real estate, until they extract all the benefits from them by raising the prices of stocks, and also the prices and indebtedness of the wealth producing properties, to such high levels that it will be again unprofitable to operate them.

Since the depression there has been a demand for unemployment insurance, also there have been enacted into law savings deposits insurance, controlled production, etc. All of these things, either as emergency measures or permanently, may be desirable in themselves, but if we let speculators inflate the capitalization of our means of production to the point where it does not pay to operate them, nobody can insure us against unemployment. If we let speculators inflate the prices of the wealth producing properties in which our savings are invested, nobody can insure our savings. If we let speculators sap the vitality of industry, no matter how industry is controlled, it cannot be made to pay.

The administration's securities control legislation and the restriction of Federal Reserve funds for brokers' loans are highly commendable, but in addition something more ought to be done to stop speculation in stocks and wealth producing properties.

True enough there are a number of factors causing the inflation of values of the means of production, such as unusual demand for goods caused by wars, etc., but even then speculation is the stepping stone to the inflation of stocks and real estate.

However, in passing legislation designed to stop speculation, it must not hinder honest business, nor must it eliminate the incentive and therefore the spontaneousness of constructive enterprise. For instance, with consumption goods such as clothing, foodstuffs, etc., the only incentive in handling them is the increase of price each time the goods change hands from producers to dealers and finally to consumers. In such a process it is hard to distinguish between a dealer and a speculator. Further, the produce speculator performs some necessary function in our marketing of raw materials and consumption goods. Therefore, this letter is limited entirely to speculation in wealth producing properties and stocks, where the speculator performs no useful function.

In its true sense investment in stocks and wealth producing properties has 2 factors, namely, amount of capital invested and length of time during which the investment will perform some socially useful function from which the earnings and capital appreciation will compensate the investor for his intelligent investment and also counterbalance the chances he took against losses.

On the other hand the speculator does not invest his money any appreciable time. To that extent he performs no socially useful function, and to that extent he is not entitled to the appreciation of capital brought about by the industry of others. Worse yet, as stated above, the meddling of speculators in capital goods has detrimental effects on society.

The following is a plan by means of which speculation will automatically be eliminated from the markets of capital goods. There ought to be a tax on all speculation profits derived from deals in stocks and wealth producing properties. This tax should be high on short time turnovers and should decrease as the length of the investment period increases.

This plan is not price fixing. In fact, a person, if he is foolish enough, may pay a great deal more than the property or stock is worth as an investment, but there will not be much incentive for any one to make him do so, nor would any one pay a high price for stocks if he knew there was no profit for him in finding some one else to pay a still higher price for that stock, and so on until the market breaks.

Such a speculation tax would not stop any one from selling his property whenever he chooses. It would not prevent him from using it as collateral for loans. It would not diminish the market for the property or securities thereof. It is bound to increase the market for same, because when property or stocks are good paying and steady investments there will be a constant demand for them, instead of the chaotic markets we have been having. To many people real estate, and particularly stocks, are precarious investments, and they keep away from them because such investments have been used like dice in the hands of gamblers.

It will not kill incentive but it will make the incentive coincident with human welfare, by drawing money to sound investments instead of to stocks and real estate for which there are expected to be the greatest number of suckers ready to hand over their hard cash for non-paying ventures.

This tax would not eliminate the stock exchanges and real estate business. It would make them steady and legitimate business unencumbered by speculators hindering and upsetting honest activities. It would make stock market activities a true business index, instead of the misleading index it has been. Also, it would not stop the flow of

wealth to the most profitable enterprises, but it would stop the flow of money to gamblers and to stock manipulators.

This tax plan will not be an expense to the government; on the contrary it will be a source of income. It does not put the government unduly into the private affairs of its citizens. It only asks the government to exercise its function as a referee, enforcing such rules and regulations as will keep the game of making a living on a more sound and ethical basis.

The writer presents the above plan and earnestly hopes that every citizen, and particularly our economists and government, will give it their consideration, or probably devise another solution to the problem. There must be some solution. We cannot continue driving the constructive units of our civilization against the wall and expect to survive.

Very truly yours,
S. J. Liacos (A'29)
(16 Park Place, Brooklyn, N. Y.)

Standards

Standards Association Acquires Added Duties

Announcement has been made of the transfer of certain functions of the U.S. National Bureau of Standards to the American Standards Association, a federation of 37 national technical societies, trade associations, and governmental bodies. Headquarters of the American Standards Association are in the Engineering Societies Building, 29 West 39th Street, New York, N. Y. The activities which are being thus transferred include:

Division of trade standards
Division of specifications
Division of simplified practice
Building code and plumbing code sections of the building and housing division
Safety code section

Following the original announcement of the contemplated change made by Secretary of Commerce D. C. Roper, the statement was made by Howard Coonley, president of the American Standards Association, that provision is being made for assuring continuity on the technical projects. A skeleton staff to be maintained in the discontinued divisions and sections of the bureau during a transition period will greatly facilitate the transfer. Individual projects in standardization and simplification can be carried on without any essential change in method. It is believed that this transfer will have far-reaching consequences for every branch of American industry concerned with standardization. The effect of the decision is to concentrate the responsibility in a single organization representative of industry, the public, and the government. The consolidation of functions in the hands of a single organization is especially important since it comes at a time when the national economy demands a sharp acceleration in standards-making to keep pace with the need for industrial agreements under the National Recovery Act.

Engineering Foundation

The Engineering Societies Library

The relations which the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers bear to the Engineering Societies Library were outlined in the statements of H. P. Charlesworth, president of the A.I.E.E., and assistant chief engineer of the American Telephone and Telegraph Company, New York, N. Y., which he delivered at a joint meeting of the boards of these 4 national engineering societies and the board of United Engineering Trustees, Inc., at Chicago, Ill., June 27, 1933, during Engineers' Week at The Century of Progress Exposition. The remarks of President Charlesworth are as follows:

The Engineering Societies Library is one of the most important coöperative activities of the 4 national societies of civil, mining, mechanical, and electrical engineers. As a composite, thoroughly indexed, and conveniently arranged library developed from the individual libraries of these 4 societies, it is well prepared to serve effectively in virtually the entire field of engineering.

Each society, in the development of its technical publications, has constantly endeavored to supply to its members the most desirable technical material originating in its own division of engineering, and has thus enabled them to keep in close touch with technical progress of the types in which they are especially interested. No society can, however, hope to supply all of the technical material, even in its own division, which its members desire. By their coöperative support and development of a single library of large proportions, the engineering societies have made readily accessible to their members the world's best engineering books and periodicals, and yet the total cost to each society has been moderate.

The thousands of members of the societies who are able to visit the library find a reading room service of high type, which assists them in locating quickly the specific information desired, and adequate, comfortable quarters in which to do their reading. The appreciation with which these opportunities are regarded is shown by the number of readers recorded in 1932, 32,882, an increase of 17 per cent over the number for 1931.

The service bureau is prepared to supply information in written form, such as photostats, reports on searches, translations, etc., and thus it meets the needs of many members, regardless of their location, who do not have access to a good engineering library or who do not find it convenient to do their own library work. Although it is necessary to charge for the major items of work done by the bureau, many inquiries for specific bits of information for which no charge can be made also are answered. The service bureau is especially helpful to the staffs of the 4 national engineering societies in answering many inquiries for various types of information which they refer to the library. Thus it renders a very important service to the society members and saves the time of staff members who otherwise would find it necessary to search for the desired information.

The book lending service of the library enables members located anywhere to borrow virtually any current American engineering book at a charge of 5 cents per day plus transportation charges.

In 1932, 70 searches and 138 translations were made. 24,675 photoprints were supplied to 3,041 persons. 250 books were borrowed by 207 persons. Letters were written to 3,519 members. 7,830 items were added to the permanent book collection.

This brief outline emphasizes the importance of maintaining the joint facilities now offered by the library and of further acquainting the members of the societies who are unable to visit it with the services which can be secured by mail. The possibilities of this type of service have been only partially realized, and it is hoped that members in general will become more thoroughly familiar with the opportunities offered. It is hoped that the 4 societies and The Engineering Foundation will be able to maintain the library on a basis at least equivalent to the present, and that as soon as conditions permit its services will be expanded in such directions as will be most beneficial to the members of the societies.

New Means of Economic Distribution Urged

Excerpts relating to engineering matters contained in the annual report for 1932 of The Engineering Foundation were given in ELECTRICAL ENGINEERING for March 1933, p. 208. Other sections of this report deal with the distribution of wealth, and emphasize that money and credit alone are insufficient to effect economic distribution of the national wealth under the new conditions imposed by science and engineering; new means of supplementing these vehicles of commerce and industry therefore must be found. Following are paragraphs on this subject, taken from the report, which was made public by H. HOBART PORTER (A'96, M'12 and life member) chairman for 1932 of The Engineering Foundation, and president of the American Water Works and Electric Company, Inc., New York, N. Y.:

"Greatly useful as are money, and credit based on money valuations of goods and services, we may well discover that among the reasons for our insufficient economic distribution is our inept persistence in using these means alone. For physical distribution of goods, energy, and ideas, we employ various suitable means. We transmit electric energy over wires; we deliver water, gas, and oil through pipes; we utilize invisible electromagnetic waves to send speech, music, and pictures to millions of persons instantly, and we are adding airplanes to railroad cars and highway trucks for transporting goods. May we not soon

devise a variety of means to supplement money sales in distributing satisfactions for our desires, and invent some new methods, or improve old ones, for exchange of services between willing workers?

"In attempting to devise additional means for distribution of both intangible and physical satisfactions of desires and needs, practical men must have constantly in mind the fact that humans still need strong incentives. Our greatest incentive is attainment of happiness through health, abundance, and a sense of security, with opportunity for exercise of our physical and mental abilities in preferred activities.

"Science has proclaimed that there may be abundance for all through practical application of truth—of the physical and spiritual laws and principles of the universe. Science is teaching also that the opportunity for abundance must be open to all who have the will to contribute their just share of service, according to ability. Men must prosper together, or they will suffer together again and again, as current experience is painfully demonstrating.

"Engineering method brings understanding, simplification, and order into complicated wastefulness as first steps out of trouble toward success. The engineering societies, through their Engineering Foundation, should share in solving mankind's problems in these critical times, with emphasis on the physical aspects, perhaps, as peculiarly the province of engineers.

"Men of other vocations, too, have methods essential to upward progress. All effective men of good-will must work harmoniously for the early adjustment of all our institutions and practices to the recent rapid advance of the sciences and their applications."

Personal Items

O. E. Buckley (M'19, F'29) formerly assistant director of research, Bell Telephone Laboratories, Inc., New York, N. Y., has recently been appointed director of research of these laboratories to succeed the late H. D. Arnold (M'16, F'29). Doctor Buckley was born at Sloan, Iowa, in 1887. He received the degree of bachelor of science from Grinnell (Iowa) College in 1909, and that of doctor of philosophy from Cornell University, Ithaca, N. Y., 1914. In 1909–10 he was instructor in physics at Grinnell College, and between 1910 and 1914 he was assistant and then instructor in physics at Cornell University. Between 1914 and 1917 he was in the engineering department of the Western Electric Company, New York, N. Y. In 1917 and 1918 he was major in the Signal Corps of the U.S. Army, in charge of the research section of the division of research and inspection of the Signal Corps of the American Expeditionary Forces. In 1919 he again became a member of the technical staff of the engineering department of the Western Electric Company, Inc., becoming a member of the technical staff of its successor company, the Bell Telephone Laboratories, Inc., in 1925. In 1928, he was appointed assistant director of research of these laboratories. In 1914 Doctor Buckley was assigned to the study of mercury arc oscillators, and later to the development of power tubes, making several important contributions in these fields. At that time he developed the ionization manometer for measuring very low gas pressures. His work during the war included submarine detection problems for the Navy. Upon returning to the laboratories after the war, he was engaged in an investigation of submarine telegraph cable, and actively promoted the application of new materials and technique which greatly increased the message capacity of such cables. Among these materials were the new iron-nickel alloy, named permalloy. The importance of this magnetic loading material led Doctor Buckley to direct a series of researches toward a better understanding of ferromagnetism, and also toward the development of better magnetic material for specific application. Numerous publications by his associates and himself have disclosed the results of this work. Many other important researches have been carried out under his guidance. On becoming assistant director of research, he was given the added duties of supervision of the group conducting researches in the field of wire transmission. Doctor Buckley is a member of the Franklin Institute, and a fellow of the American Association for the Advancement of Science, and the American Physical Society. Doctor Buckley has served the Institute as a member of the electrophysics committee continuously since 1926, having been chairman for the years 1929–31. Between 1929 and 1931 he also was a member of the meetings and papers (now technical program) committee. He also has contributed to the technical literature of the Institute.

O. E. BUCKLEY

W. E. Wickenden (A'07, M'13) president of Case School of Applied Science, Cleveland, Ohio, has been elected president of the Society for the Promotion of Engineering Education for the year 1933–34. He was born at Toledo, Ohio, in 1882. In 1904 he graduated from Denison University, Granville, Ohio, with the degree of bachelor of science, and took graduate work in electrical engineering at the University of Wisconsin, Madison, for 2 years. He was instructor in physics and applied electricity at the Rochester (N. Y.) Mechanics Institute, 1904–05, and between 1905 and 1909 was assistant in physics and later an instructor in electrical engineering at the University of Wisconsin. Between 1909 and 1916, he was assistant professor of electrical engineering at Massachusetts Institute of Technology, Cambridge, becoming associate professor in 1916. In 1917 he was supervisor of educational work for the engineering department of the Western Electric Company, New York, N. Y., becoming manager of a newly created personnel department of this company in 1918. Later he was named chairman of the Western Electric Company's personnel committee. In 1921 he was transferred to the headquarters' staff of the American Telephone and Telegraph Company, New York, as assistant vice-president in charge of the recruiting and development of supervisory and technical personnel for the companies comprising the Bell system. This work included the promotion of relations with universities and colleges throughout the country. Between 1923 and 1929 he was director of investigation for the Society for the Promotion of Engineering Education, becoming president of Case School of Applied Science in the latter year. Doctor Wickenden has made many contributions to the literature on engineering education, and is the author of "Illumination and Photometry." He is a member of The American Society of Mechanical Engineers, the American Association of Political and Social Science, the American Association for the Advancement of Science, and the Cleveland Engineering Society. He is director of the Adult Education Association of Cleveland, and a trustee of Cleveland College. He has received the honorary degrees of doctor of engineering from Lafayette College, 1926, Worcester Polytechnic Institute, 1927, and Case School of Applied Science 1929; he also has received the honorary degree of doctor of science from Denison University, 1928, and Bucknell University, 1930, and that of doctor of laws from Oberlin College, 1930.

J. B. Whitehead (A'00, M'08, F'12, life member and president) dean, school of engineering, Johns Hopkins University, Baltimore, Md., has been appointed representative of the Institute on the assembly of American Engineering Council, taking the place of H. P. Charlesworth (M'22, F'28 and junior past-president) assistant chief engineer of the American Telephone and Telegraph Company, New York, N. Y. Doctor Whitehead also takes the place of Mr. Charlesworth as the Institute's representative on the Charles A. Coffin fellowship and research fund committee.

H. P. Charlesworth (M'22, F'28, and junior past-president) assistant chief engineer, American Telephone and Telegraph Company, New York, N. Y., has been appointed representative of the Institute on the John Fritz Medal board of award.

Technical Committee Chairmen Reappointed for 1933-34

The group of chairmen of the Institute's technical committees reappointed for the year 1933–34 are presented herewith. Biographical sketches of these chairmen were given in the personal columns of ELECTRICAL ENGINEERING for September, October, and November 1932, in connection with their appointment or reappointment to these positions for 1932–33. Biographical sketches of the technical committee chairmen newly appointed for 1933–34 are scheduled for future issues.

H. S. OSBORNE
Communication
Transmission Engineer, American Telephone and Telegraph Company, New York, N. Y.

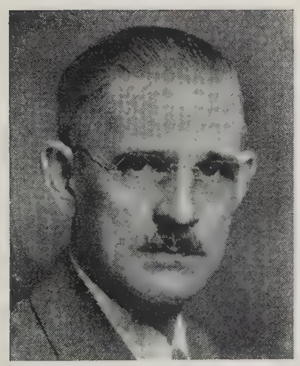
F. O. SCHNURE
Applications to Iron and Steel Production
Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Md.

D. W. TAYLOR
Automatic Stations
Assistant Electrical Engineer, United Engineers and Constructors, Inc., Newark, N. J.

K. L. HANSEN
Electric Welding
Consulting Engineer, K. L. Hansen Engineering Company, Inc., Milwaukee, Wis.

R. T. HENRY
Protective Devices
Electrical Engineer in Charge of Design, Buffalo, Niagara and Eastern Power Corp., Buffalo, N. Y.

S. L. HENDERSON
Electrical Machinery
Division Engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.



W. C. KALB
Electrochemistry and Electrometallurgy
Carbon Sales Division, National Carbon Company, Cleveland, Ohio

C. W. RICE
Research
Assistant to Vice-President in Charge of Engineering, General Electric Company, Schenectady, N. Y.

E. L. MORELAND
Transportation
Jackson and Moreland, Consulting Engineers, Boston, Mass.

J. W. Owens (A'10, F'27) has been appointed consulting engineer and director of the newly organized national weld testing bureau of the Pittsburgh Testing Laboratory, Pittsburgh, Pa. The bureau proposes to render a complete welding service to manufacturers, fabricators, contractors, and firms or corporations, along the lines of reports and tests on welds. For the past 3 years Mr. Owens has been in private consulting practice, and for $4^1/_2$ years prior to this he was director of welding at the Newport News Shipbuilding and Drydock Company. He has been active in the welding field for 15 years. He is a member of several committees of the American Standards Association and of the American Welding Society, having also served the latter organization as its vice-president 1920–22, and at present as director. He is also a member of the American Bureau of Welding, the American Society of Naval Architects and Marine Engineers, and The American Society of Mechanical Engineers.

Alfredo Baños, Jr. (A'31) who has been research assistant in electrical engineering at The Johns Hopkins University, Baltimore, Md., has, with his co-author, J. B. Whitehead (A'00, M'08, F'12, life member and president) received the 1932 A.I.E.E. national prize for best paper in theory and research. The title of their paper is "The Predetermination of the A-C Characteristics of Dielectrics." Mr. Baños was born in Mexico City in 1905. He attended the University of Texas between 1923 and 1926, and The Johns Hopkins University between 1926 and 1928, receiving the degree of B.E. from the latter institution in 1928. For the latter half of 1928 he was research assistant, Brooklyn Edison Company, Brooklyn, N. Y., becoming research assistant in electrical engineering at The Johns Hopkins University, at the end of 1928. Mr. Baños is now in Mexico City.

C. W. LaPierre (A'28) an electrical engineer for the General Electric Company, Schenectady, N. Y., has received honorable mention in connection with the 1932 A.I.E.E. national prize for best paper in theory and research for his paper entitled "The Photoelectric Recorder." Mr. LaPierre was born in Jackson, Mo., in 1904. He attended Missouri State College for one year, and then spent 2 years at the school of engineering of the University of Missouri. In 1923 he joined the organization of the General Electric Company at Schenectady, being in the test department for a few months, and then being transferred to the general engineering laboratory. In 1928 he was transferred to the switchboard engineering department of the company at Philadelphia, Pa., subsequently returning to his present position in Schenectady.

K. R. Eldredge (Enrolled Student) has received honorable mention in connection with the 1932 A.I.E.E. national prize for Branch paper for his work entitled "A New Wattmeter for Communication Circuits." He was born in Portland, Ore., in 1909, and studied electrical engineering at Oregon State College, Corvallis, having received the degree of bachelor of science this year. The paper for which he was awarded honorable mention was presented at a joint meeting of the Portland Section of the A.I.E.E. and the N.E.L.A., and the Oregon State College Branch, May 21, 1932.

L. L. Mundell (Enrolled Student) has, with his co-author W. C. Spear (Enrolled Student) received honorable mention in connection with the 1932 A.I.E.E. national prize for Branch paper. The title of their paper was "A New Method of Measuring Angular Displacement," and was presented at a meeting of the University of Colorado Branch, May 18, 1932. Mr. Mundell was born in Ordway, Colo., in 1910. He took the electrical engineering course at the University of Colorado, receiving the degree of B.S. in E.E. in 1932.

W. C. Spear (Enrolled Student) has, with his co-author, L. L. Mundell (Enrolled Student) received honorable mention in connection with the 1932 A.I.E.E. national prize for Branch paper, for their work entitled "A New Method of Measuring Angular Displacement." This paper was presented at a meeting of the University of Colorado Branch on May 18, 1932. Mr. Spear was born at Keene, N. H., in 1910. In 1932 he graduated from the electrical engineering course of the University of Colorado with the degree of B.S. in E.E.

C. F. Scott (A'92, F'25, HM'29, member for life and past-president) who, at the end of the college year recently completed, retired from the position of professor of electrical engineering and head of the department at Yale University, New Haven, Conn., has been appointed representative of the Institute on the U.S. national committee of the International Commission on Illumination.

E. J. Rutan (A'20, M'29) superintendent of the testing department, New York Edison Company, New York, N. Y., has been elected chairman of the recently organized sectional committee on electrical measuring instruments of the American Standards Association. The work of the committee will be handled by 2 subcommittees, one on definitions, and the other on classification, rating, methods of testing, and construction.

Gerard Swope (A'99, F'22) president of the General Electric Company, New York, N. Y., has been appointed permanent chairman of the business advisory and planning council for the U.S. Department of Commerce. Concisely the broad purpose of the council is to bring business into the closest possible coöperation with the government.

C. A. Adams (A'94, F'13, member for life and past-president) Lawrence professor of engineering, Harvard University, Cambridge, Mass., has been appointed representative of the Institute on the council of the American Association for the Advancement of Science, replacing the late F. W. Peek, Jr. (A'07, M'13, F'25, and director 1929–33).

D. C. Jackson (A'87, F'12, member for life and past-president) professor of electric power production and distribution, and head of the department of electrical engineering, Massachusetts Institute of Technology, Cambridge, has been appointed representative of the Institute on the engineering division of the National Research Council.

W. S. Gifford (A'16) president, American Telephone and Telegraph Company, New York, N. Y., has been appointed chairman of the committee on statistical reporting and uniform accounting for industry, which is part of the business advisory and planning council for the U.S. Department of Commerce.

D. C. Green (M'26) formerly vice-president, Electric Bond and Share Company, New York, N. Y., has recently been elected president of the Middlewest Utilities Company, central organization in the former Insull utility system. He will take complete charge of operating companies controlled by Middlewest Utilities in 18 states.

F. B. Jewett (A'03, F'12, and past-president) vice-president of the American Telephone and Telegraph Company, and president of the Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed representative of the Institute on the engineering division of the National Research Council.

L. T. Merwin (A'10, M'33) vice-president and general manager of the Northwestern Electric Company, Portland, Ore., was elected president of the Northwest Electric Light and Power Association at its 26th annual meeting held in Portland late in July.

R. S. Wallace (A'03) formerly executive vice-president and general manager of the Central Illinois Light Company of Peoria, Ill., has been elected president of that company. His appointment follows the recent merger of the Central Illinois Light Company and Illinois Power Company.

H. C. Koenig (A'18, M'30) engineer in charge, electrical laboratory, Electrical Testing Laboratories, New York, N. Y., has been elected secretary of the recently organized sectional committee on electrical measuring instruments of the American Standards Association.

M. E. Leeds (A'01, F'26) president, Leeds and Northrup Company, Philadelphia, Pa., has been appointed a member of the committee on decentralization of industry which is part of the business advisory and planning council for the U.S. Department of Commerce.

E. B. MEISSNER (A'16) president and general manager of the St. Louis Car Company, St. Louis, Mo., will represent street car and bus manufacturers on the industrial recovery conference committee of the Associated Industries of Missouri, for the eastern half of the state.

J. J. BOOTH (A'13, M'28) superintendent of the electrical department of the National Tube Company, Gary, Ind., will continue to serve the Association of Iron and Steel Electrical Engineers as an officer for the year 1933–34, with the title of past-president.

H. S. WARREN (A'03, F'13) protection development engineer, American Telephone and Telegraph Company, New York, N. Y., has been appointed alternate representative of the Institute on the electrical committee of the National Fire Protection Association.

L. W. CHUBB (A'09, F'21, and director) director of the Westinghouse research laboratories, East Pittsburgh, Pa., has been appointed a representative of the Institute on the engineering division of the National Research Council.

W. N. GLADSON (A'92, M'02) dean, college of engineering, University of Arkansas, Fayetteville, has been elected a member of the council for the Society for the Promotion of Engineering Education for the year 1933–34.

E. W. BOEHNE (A'29) formerly in the a-c engineering department of the General Electric Company, Schenectady, N. Y., is now in the large oil circuit breaker engineering department of the company at Philadelphia, Pa.

K. T. COMPTON (F'31) president, Massachusetts Institute of Technology, Boston, has been elected a member of the council of the Society for the Promotion of Engineering Education for the year 1933–34.

C. H. WILLIS (A'22, M'28) Princeton University, Princeton, N. J., has been elected a member of the council of the Society for the Promotion of Engineering Education for the year 1933–34.

H. R. BLOMQUIST (A'25) formerly engineer for the New England Power Association, Needham, Mass., is now in the research department of the United Electric Railways Company, Providence, R. I.

A. S. GOLDMAN (A'28) formerly division manager of the California Public Service Company, Fort Bragg, Calif., is now district manager of the Western States Utilities Company at Winnemucca, Nev.

E. W. BULL (A'10, M'25) superintendent of light and power, city of Regina, Saskatchewan, Can., has been given control of the railway department of the city.

Obituary

FRANK WILLIAM PEEK, JR. (A'07, F'13, F'25, and director 1929–33) chief engineer of the Pittsfield, Mass., works of the General Electric Company, was killed July 26, 1933, when his automobile was struck by a train near Gastones on the Gaspe Peninsula of Canada. Mr. Peek was probably best known, both to the electrical engineering profession and to the public, by his work in the field of lightning research. He was born at Mokelumne Hill, Calif., in 1881. In 1905 he graduated from Leland Stanford University, Calif., with the degree of bachelor of arts; in 1911 he received the degree of master of electrical engineering from Union College, Schenectady. During vacations while in college he was an electrician for the Standard Electric Company and the California Gas and Electric Company. In 1905 he became a test man at the Schenectady, N. Y., works of the General Electric Company, remaining in this position until 1906, when he became head of a special test in engineering research. In 1907 he joined the power and mining engineering department of the company, beginning his original researches which first drew attention to him as an investigator of high voltage phenomena. During the summers of 1907 and 1908 he studied lightning and the protection of electric transmission lines from lightning, in the mountains of Colorado. In 1909 he joined the newly formed consulting engineering department of the company organized by Dr. C. P. Steinmetz. During the following 2 years he was engaged in studying the problem of electric transmission at 250,000 volts, and it was during this period that he established the laws of corona and also investigated line insulators. Mr. Peek was transferred from Schenectady to the Pittsfield Works of the company in 1916 to specialize on high voltage, power transmission, and related developments. Since that time he has been increasingly active in the investigation of lightning and has directed the building of several lightning generators. Mr. Peek has been a frequent contributor to the literature of the Institute, his papers including valuable information on the laws of corona, measurement of high voltage, electrical strength of air, oil, and solid insulation, and other high voltage phenomena. He also has contributed practical papers on engineering problems and transmission line calculations. His contributions to various sources exceed 200 articles. Numerous inventions in the field of high voltage transmission also have been made by Mr. Peek. He was the recipient of the Thomas Fitch Rowland prize of the American Society of Civil Engineers in 1923, and the Levy Medal of the Franklin Institute in 1926, awarded for "researches in physical science and engineering achievements in lightning." Mr. Peek was a fellow of the American Physical Society, and a member of the Franklin Institute, the American Society for the Advancement of Science, and Sigma Xi scientific fraternity. He has served the Institute on 9 of its committees over a period of many years, having been chairman of 3 of these, and has served as the Institute's representative on several other bodies.

AUGUSTINE ROBERT EVEREST (A'04, M'04) consulting engineer for the British Houston Company, Ltd., Rugby, England, died July 15, 1933. He was born in 1866 at Lymington, Hampshire, England. After studying under a tutor and at Solent Collegiate School, Lymington, he attended classes of the science and art department, South Kensington, and "City Guilds" classes in electrical engineering. He also studied at King's College, London. He served his apprenticeship of 7 years with Siemens Brothers and Company, Ltd., Woolwich, in the instrument making and testing departments. In 1887 Mr. Everest joined the engineering staff of the P. & O. Steamship Company. Two years later he came to the United States, entering the service of the Thomson Electric Welding Company, Lynn, Mass. In 1896 he joined the Thomson Houston Company (later the General Electric Company) being engineer in charge of the alternating department for several years. In 1905 he returned to England to join the engineering staff of the British Thomson Houston Company, Ltd. Up to the time of his appointment in 1914 as consulting engineer to the engineering and manufacturing departments of this company at Rugby, Mr. Everest had been designer of a-c apparatus and also had acted as chief advisor in regard to special tests and investigations relating to insulating material. Mr. Everest was active on many committees serving the electrical industry, having been chairman of several of these. He was chairman of the B. E. A. M. A. (Great Britain) standardizing committee for 21 years, and was one of the most active workers on the British Standards Institution committee. He was active in the work of the International Electrotechnical Commission, and also on committees of the Electrical Research Association, having been chairman of the council of this latter organization for 2 years, and also chairman for many years of the B. E. A. M. A. research committee. He was a member of the Institution of Electrical Engineers (Great Britain), the Faraday Society; the Institute of Radio Engineers, and the American Society for Testing Materials.

FRANK HUGO BERNHARD (A'07, M'21) with Frank Fowle and Company, Chicago, Ill., died March 4, 1933. At the time of his death he had just concluded his duties as assistant to the editor-in-chief of the "Standard Handbook for Electrical Engineers," sixth edition. Mr. Bernhard was born in Freiberg, Moravia, Austria-Hungary, in 1875. He was educated in the public schools of Chicago, Ill., and attended Armour Institute of Technology, graduating in 1901, with the degree of B.S. in E.E. In 1917 he received the degree of electrical engineer from the same institution. Between 1901 and 1903 he was in charge of the testing department of the storage battery factory of Helios-Upton Company, Chicago. Between 1903 and 1907 he was instructor in electrical engineering at Armour Institute. Between 1907 and 1908 he was assistant editor of "Western Electrician," and between 1908 and 1909 was associate editor of "Electrical Review and Western Electrician." Between 1909 and 1910 he was assistant managing editor of the same pub-

lication. After a 3 months' leave of absence, due to serious illness brought on by overwork, he became associate editor of the same publication, continuing in this position until 1917 when he became engineering editor of "Electrical Review," the condensed title of the same publication. During the first 3 months of 1920 he was managing editor of this publication in full charge of the editorial department. He then became editor of "E. M. F. Electrical Yearbook" organizing the editorial work and staff of a new annual publication, comprising an electrical dictionary, encyclopedia, and directory of manufacturers. Mr. Bernhard continued active in other editorial duties up to the time of his death. He was a member of the Illuminating Engineering Society, Western Society of Engineers, and the Electric Club of Chicago.

Lee Boyer (A'12, M'22) general manager, Consolidated Power and Light Company, Deadwood, S. D., died recently. He was born in Union County, Ohio, in 1880; he attended Ruskin College. He was in the construction department of the Western Union Telegraph Company in 1900–01, and during 1902 was in the engineering department of the National Signal Company. Between 1903 and 1905, he was manager and engineer for the Okmulgee (Okla.) Light and Power Company, and between 1905 and 1907 was engineer in a consulting capacity for the Southwestern Development Company. In 1907 and 1908 he was engaged in construction of a power plant for the J. C. Drinkle Company at Saskatoon, Saskatchewan. In 1908 he also was engineer and manager of the Central Light and Power Company at Wolseley, Saskatchewan. In 1909 he was engaged in construction for the Weber Gas Engine Company at Fairview, Okla., and between 1909 and 1910 was manager and engineer for the Sapulpa (Okla.) Electric Company. In 1910–12 he was superintendent of the hydroelectric properties of the Consolidated Power and Light Company, Deadwood, S. D., and between 1912 and 1917 was general superintendent of this company. Between 1917 and 1919 he was general superintendent of the Chictaw Power and Light Company, and the Pittsburgh County Railway, both at McAlester, Okla. In 1919 he became general manager of the Consolidated Power and Light Company at Deadwood.

Albert Lee Harvey (A'09, M'13) industrial control engineer of the Chicago, Ill., office of the Westinghouse Electric and Manufacturing Company, died at Randolph, Neb., July 9, 1933. He was born at Hawarden, Iowa, in 1885. After attending Bellevue College, Bellevue, Neb., for one year, he entered the University of Nebraska, graduating with the degree of B.S. in E.E. in 1906. He was then engaged in wiring, repair, and construction work with various contractors during summer vacations. Following graduation he spent 2 years on switchboard diagrams and design for the Westinghouse Electric and Manufacturing Company, and was then foreman for the Union Electric Company, Lincoln, Neb., for several months. After being engaged in electrical contracting for a while, he returned to the Westinghouse company in 1909 as a switchboard designer, and in 1910 undertook switchboard estimating and power and substation design for this company. In 1914 he undertook controller application and estimating for industrial purposes for the Westinghouse company, and in 1916 devoted his time to machine tool controllers and d-c automatic starters. In 1925 he was transferred to the Chicago office. He was considered an authority on industrial motor application and control.

Francis Lafayette O'Bryan (M'22) district manager, Edison Electric Illuminating Company of Boston, at Framingham, Mass., died August 1, 1933. He was born in Martinsville, Va., in 1878. Between 1900 and 1902 he was engineer for the Fries Manufacturing and Power Company, Winston-Salem, N. C. Between 1902 and 1903 was assistant construction superintendent for the Niagara Hydraulic Manufacturing Company, Niagara Falls, N. Y. Between 1903 and 1910 he was assistant electrician and mechanical engineer for the Boston and Worcester Street Railway Company, Framingham, Mass. Between 1910 and 1916 he was electrical and mechanical engineer for this company. In 1916 and 1917 he was assistant purchasing engineer of the Edison Electric Illuminating Company of Boston. Between 1917 and 1920 he was electrical safety engineer for the Liberty Mutual Insurance Company, Boston, Mass. It was in 1920 that he became district manager of the Edison Electric Illuminating Company at Framingham.

Charles Lyman Fortier (M'21) consulting engineer, Johnson Service Company, Milwaukee, Wis., died February 21, 1933. He was born at Kingston, Ontario, in 1852. Between 1870 and 1887 he was with the Montreal Telegraph Company, the Pacific and Atlantic Telegraph Company, the Western Union Company, and the Chicago and Milwaukee Company; with these companies he held positions of operator, wire chief, office manager, and division manager. Since 1887 he has been with the Johnson Electric Service Company, and the Johnson Service Company, with the exception of a few years during which time he perfected a printing telegraph for the Gilmore Printing Telegraph Company.

Walter Christopher Mangels (A'16 M'31) system operator, electric department, Public Service Electric and Gas Company, Newark, N. J., died July 16, 1933. He was born in Jersey City, N. J., in 1884. Following attendance at high school, he gained further education by private instruction. For the past 33 years, Mr. Mangels has been in the employ of the Public Service Electric and Gas Company and its predecessor companies, having been engaged in substation and central station, transmission, distribution, and general operating work. In 1919 he was placed in charge of all load dispatching and system operation throughout the Public Service Electric and Gas Company's territory.

Harry Arthur Curtis (A'17, M'27) chief engineer and general manager, hydroelectric department, Government of Tasmania, Hobart, Tasmania, died May 20, 1933. He was born in 1882 at Lyttelton, New Zealand, and studied at Canterbury College, University of New Zealand. Between 1904 and 1912, he received practical experience in general engineering work in England. Between 1912 and 1914 he was assistant engineer, Cashmere State and City Council, Christchurch, New Zealand. Between 1914 and 1916 he was assistant engineer on construction of the Lake Coleridge hydroelectric station, New Zealand. In 1916 he became power station superintendent of the hydroelectric department, Tasmania, and in 1919 became chief operator of this department in charge of power stations, substations, and transmission lines. Between 1920 and 1923, he was construction engineer for this same department, and between 1923 and 1924 was engineer for electrical design of the hydroelectric department. In 1924 he was appointed chief assistant engineer of this department and later the same year was appointed to the position of chief engineer and general manager.

Emanuel William Sundberg (A'18) designer, Brooklyn Edison Company, Brooklyn, N. Y., died May 5, 1933. He was born in Stockholm, Sweden, in 1873. He attended the Technical School at Stockholm, graduating in 1895 with a mechanical engineering degree. Between 1898 and 1902, he was electrical and mechanical designing draftsman for the General Electric Company, Lynn, Mass., the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and the Crocker-Wheeler Company, Ampere, N. J. In 1902 he was chief draftsman for the Roland Telegraph Company, Baltimore, Md., and between 1903 and 1908 held a similar position with the National Electric Signaling Company of Pittsburgh, Pa. Between 1908 and 1910 he was superintendent of works, Hipwell Manufacturing Company, Allegheny, Pa. Between 1910 and 1914 he held a similar position with the Reliable Electric Manufacturing Company, Worcester, Mass. In 1914 he became designer for the Wagner Electric Manufacturing Company at St. Louis, Mo., subsequently joining the organization of the Brooklyn Edison Company.

Local Meetings

Future Section Meeting

Lehigh Valley

Sept. 30—Annual inspection trip of 1933–34 season to be held on Saturday, Sept. 30, 1933, at Hershey Park, Pa., at 10 a.m. eastern standard time. An inspection will be made of the chocolate factory and modern power plant (16,000-kw demand) in which a new turbine generator recently has been installed. The industrial school at Hershey Park together with other points of interest also will be opened for inspection. Those attending will have their choice of basket lunch or lunch at the cafeteria. In the afternoon sports will be available.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Construction

PRACTICAL ELEC CONSTR FOREMAN, 32, single, desires work along elec constr and maintenance lines. Fourteen yr practical experience in the erection, constr and operation of industrial plants and mines. Last 4 yrs spent in mining camps in So. Am. Working knowledge, German, Spanish. Willing to travel anywhere, available immediately. Location immaterial. C-2101

GRAD E.E., 35, 6 yrs pwr plant elec operation, both hydro and steam. Dispatching and system operation; inspection; 5 yrs cost acctg. Desires position with util, engg, or constr concern. Location immaterial. Available immediately. C-7796

PRACTICAL ELEC CONSTR FOREMAN, 35, single. Desires work along elec constr and maintenance lines. Nine yrs experience in constr line. Willing to travel anywhere. Location immaterial. Available immediately. D-2441

Design and Development

ELEC-MECH ENGR, 32, col grad; 10 yr diversified experience including $1^1/_2$ yr pwr plant operation and maintenance; $2^1/_2$ yr G.E. test and central station engineering; $2^1/_2$ yr design, constr and system devpmt for large util; $3^1/_2$ yr plant engg with large industrial concern. C-5727

ENGR, 31, 12 yrs Bell system and govt plant and field experience on sound picture, radio and telephone (manual, dial, repeater and carrier current) systems. Design and devpmt of manual and automatic elec testing equip. Industrial applications of electron tubes. Available immediately. C-9376.

E.E. Grad, 28, married, desires position in design and devpmt or teaching. One yr Westinghouse student course; 6 mos Westinghouse design school; $1^1/_2$ yrs design of fractional hp motors; $2^1/_2$ yrs design of industrial motors. Available at once. Location, United States. C-5051.

ELEC ENGG, married, univ grad E.E. & M. E., 22 yrs experience design, constrn pwr plants, substations, transmission, distribution systems; 3 yrs exec experience charge engg dept. large util syndicate; 3 yrs purchase engg equip for foreign interest. Languages, English, German, Russian, Armenian, and Turkish. Available immediate service design, constr, operation or purchasing. D-84

ELEC ENGR, 10 yrs experience. B.S. Worcester P.I. 1922. E.E. 1924. Assoc. A.I.E.E. '25, Member '32 Section chairman '32. Single, 32. Eight yrs experience Westinghouse transformers and auxiliaries, 2 yrs exec experience. Possesses inventive and natural ability, personality and adaptability. Capable of assuming responsibility. Location immaterial, New England preferred. D-1443

B.S. in E.E., 1927, single, 1 yr d-c test and design, 4 yrs design and application of outside plant hardware at Bell Lab, and out-of-hour courses. Available at once. D-1305

ELEC DESIGNER, 33, married, equivalent of a col education; 15 yrs experience on automatic ry substations, 4-kv to 230-kv substations, hydro-elec and steam pwr plants and low tension net work systems. Available immediately. Location immaterial. B-8628

Executives

E.E., 15 yrs experience, util, elec mfr and prominent engg concern. Responsible charge elec work steam and hydro plants. Familiar economic and financial problems. Grad study in business administration this past yr. Desire administrative opportunity mfr or financial organization. New England location preferred. D-2351

TRANSMISSION SYSTEM OPERATING ENGR, univ grad, 12 yrs operating experience, 4 yrs gen engg office. Specialized relay applications including distance; symmetrical component studies; pwr circle diagram; stability studies, transient and steady state; latest lightning protective methods and all problems connected with system disturbances. Available. C-9291

E.E., 41, tech grad, 19 yrs active experience, past 10 yrs E.E. for util serving 45,000 consumers. Specialized in distribution and relay work but competent in any phase of util engg. Location immaterial. B-8058

TECH GRAD, 15 yrs experience covering testing and designing of elec motors and generators. Experienced also in compiling engg and tech data and preparation of specifications. Location immaterial. Available immediately. D-2396

BUSINESS EXEC-ECONOMIST. Asst chief elec division, Dept Commerce. Desire work in market analysis, trade promotion, economic research, teaching engg, mathematics. B.S. in E.E. 1920. Thirteen yrs business experience including pwr plant design, RR, market analysis for large elec mfrs. Author publications, articles in tech journals. 35, married. B-3598

EXEC, 45, $22^1/_2$ yrs as top exec in util and industrials; wide engg and gen business experience; desires responsible position in any line where experience, sound judgment, common sense and unbounded energies can be made mutually beneficial; available Sept. 1, mutually satisfactory remuneration will suggest itself at interview. D-2410

UTIL ENGR, 31, 10 yrs util. exp. principally with client cos of Elec Bond and Share, includes design, constr, and operation of transmission and distribution systems, investigations and economic studies, networks, reconstruction and devpmt planning, annual budgets, acctg and gen engg work affecting more economical operation and maintenance of facilities. B-6934.

DESIGN ENGR, col grad, 15 yrs experience as switchbd engr with large mfg co. Wide experience in selection, application of all apparatus going into elec serv. Also actual experience in making, checking wiring diagrams, drawing room methods, as shop contact man, checking, inspecting, estimating and project work. Util experience. D-2166

EXEC ASST, Mr. Chief Executive you need your time for bigger things. I will take your mfr problems off your hands and operate your plant at lowest possible cost. I have done this in elec and mech lines. Desire to get connected with firm where hard work and ability are appreciated. D-2076

EXEC ASST, 33, univ grad, 9 yrs merchandising and util experience, foreign languages. Available immediately. Location, New York or foreign. C-3534

PUBLIC ADDRESS, RADIO BROADCASTING, or CARRIER work desired by E.E., 34, married. Four yr design, constr, operation, testing of equip for elec pwr stations, 6 yr installation, wiring and testing of radio broadcast, tel and tel repeaters, and carrier equip. Excellent references. D-733

Instruction

E.E., M.E.E., Bklyn Poly Inst, 1933, single, 23, good scholastic record, excellent knowledge of operational calc. Desires position as instr in E.E. or math, or work in any elec field. Salary and location immaterial. Available now. D-2348

TEACHING POSITION IN SCIENTIFIC COL DESIRED BY E.E., 37, M.I.T. grad. Experience includes $1^1/_2$ yrs teaching elec engg in first class univ and several yrs tech writing. At present teaching elementary and advanced physics in scientific high sch.; in this school $1^1/_2$ yrs Married. Ensign in Navy during war. C-2481

E.E., grad Kansas St Col, 1930, married, 29. One yr util training course, 8 mos util engg. One yr gen maintenance with automobile mfr., 1 yr teaching experience. Excellent references. Desire RR electrification, util or teaching position. D-2407-4674-Chicago

INSTR or ASST PROF, 38, 8 yrs instructor in E.E., radio, physics, in important univ; 5 yrs commercial experience, ltg, pwr, radio installations, research and design. Available for next Sept. C-6302

AVAILABLE AT ONCE ELEC ENGR. Ten yrs experience covering gen installation and maintenance, sound equip and acoustics, oil burner and heating equip, production of radio elec, compass and specialties. Instructor automatic electricity and industrial electricity. Licensed master electrician, Mass. Prefer sound or automatic control work. Go anywhere. D-615

Junior Engineers

YOUNG E.E., 28, single, with experience in mech and elec manufacture available for employment. Actual experience in the design, testing and estimating the cost of mech and elec equip. Location preferred, East. C-5130

JR ENGR, I.E.E. Grad., Pratt Inst., 1933, 21, single, good references. Two yrs experience as salesman of elec equip and appliances. Honest and reliable. Willing and hard worker. Height 5′$7^1/_2$″, English-Swedish decent. Presbyterian. Any location. Salary secondary. Available immediately. D-2356

B.S. in E.E., Lehigh Univ, 1930, single, 25, Tau Beta Pi. Two yrs communication experience with Am Tel & Tel Co. (long lines dept), 4 mos Edison Co testing pwr plant and substation equip. Available now. Location immaterial. D-2380

B.S. in E.E., 1933, Milwaukee Sch of Eng, 23, single. Earned way through col. Good scholastic record. Desires position affording experience and possible advancement. Salary and location secondary. Available immediately. D-2381

E.E. GRAD, 1931, 10 mos experience with large belting mfr as asst engr; $1^1/_2$ yrs sales experience. Wish to connect with large engg corp. Location and salary secondary although East preferred. Married and willing worker where chance for advancement is assured. C-9422

E.E. GRAD, 1933, honor student, 25, single. Communication major, 4 yrs lab asst in sound recording lab. Desires tech work in sound. Good references. Location immaterial. D-239

B.S. in E.E. 1930, 26, single. Four yrs inspection dept; 1 yr elec test equip maintenance; 2 yrs calibrating elec testing equip. Also some machine shop and research experience. Has designed some small apparatus. Desires position with util,

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St. San Francisco — 205 West Wacker Drive Chicago — 31 West 39th St. New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge, repeated only upon specific request and after one month's interval. Names and records remain on file for three months, renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra three-cent stamp enclosed for forwarding.

mfg or constr co. Will go anywhere. Available immediately. D-2366

B.S. in E.E. 1930, M.S. in E.E. 1931. Married, 25, no physical defects. M.S. deg with honors. Experienced in gen elec serv and contr; 1 summer in relay dept pwr co, 1 yr teaching elec. Any kind of elec refrg, or air conditioning work is greatly needed. D-1198

B.S. in E.E., 1931 grad, single, 25, desires position in E.E., preferably teaching or research. Two summers experience with elec contracting co. Grad asst at coll 18 mos. Member Tau Beta Pi. References. Salary and location secondary. Available immediately. D-1259

EARNEST, RESPONSIBLE YOUNG MAN wishes position as asst to purchasing agt or exec. Col grad (E.E. 1928). Acctg and office experience. Also specification and acceptance test writing; some purchasing; price estimating; statistical studies; design and tech corres. D-2417

E.E. GRAD, R.P.I. 1933, member of Sigma Xi, 22, single. Experience in pwr engg; can type. Character of engg work and location immaterial. Available immediately. D-2313

CASE GRAD, B.S. in E.E., married, 29, tech adv, testing, design, constr supervision. Specialized in ry signaling. Now employed in relief administration. Desires permanent position in tech, tech adv or personnel work. Location immaterial. D-870

B.Sc. in E.E. Rutgers, 26, single. Eight mos experience in mfg, 2 yrs experience in drafting. Desires permanent position with reliable co. Location East preferred. Available immediately. D-2402

S.B. in E.E., M.I.T. '31. Grad work at Stanford. Specialist in communications. Speak Spanish and French. Will go anywhere. 27 and married. D-2428

TECH COL GRAD, 22, fine record, Japanese Am. Desires experience with low wages. Understands Japanese. Pacific Coast preferred. D-2429

COMMUNICATIONS, B.S., M.S. in E.E. Case '32. Single, 23, member Sigma Xi, Tau Beta Pi. Grad studies and research in elec networks, radio, electronics. Knows tech German and French, shorthand, typing. One yr teaching asst. Desires position, communications field where above training will be useful. Location, Northeastern quarter of U.S. preferred. D-2424

B.S. in E.E., Lehigh U., 1933, 22, single. Newtonian Society, Pi Mu Epsilon, pres Eta Kappa Nu, sec'y. Student Branch A.I.E.E., grad with honors, good mathematician, 2 yrs experience drafting, some wiring and repair, typing, desires position in any engg field. Location immaterial. Available immediately. D-2418

JR ENGR, B.S. in E.E. 1933, New York University, 21, single. Industrious and willing to do any sort of work in electrical line. Some industrial experience. Conversant in Spanish. Can furnish best character references. Location and salary secondary. D-2413

B.S. in E.E., M.I.T., 1933, honor student, 21, single. One yr of clerical and drafting work with a util, also experience in surveying. Interested primarily in research or devpmt work. Prefers N. J. or N. Y. location. Salary secondary. References. D-2440

E.E., '32 and M.E.E., '33, R.P.I., 23, single. Member of Sigma Xi. Desires any position in E.E. field. Specialized in pwr and light. Salary secondary, location immaterial. Available at once. D-2438

B.S. (physics) and E.E. Recent grad, 22, single. Mathematically inclined. Radio experience. Desires position, preferably in engg field. Excellent references. Location and salary secondary. D-2443

B.S. in E.E., 1933, single, 23. Tau Beta Pi, Theta Tau. Honor Student. Industrious, energetic, and anxious to obtain work of any kind. Experience includes elec. constrn, maintenance, drafting and lab. work. Salary and location secondary. D-2442

GRAD E.E., Univ of Wis, 24, single. Training in communications engg. Speak German and read French. Four yrs varied experience with telephone systems. Excellent references. Interested in study, devpmt and constn of communication systems particularly foreign enterprise. Desire experience and opportunity. Salary secondary. Preference for N. Y. C. at present. D-2409

B.S. in E.E., 1932, single, 24, honor student, Phi Kappa Phi. Specialized in transmission and distribution. Knowledge of practical radio work. Four mos with G.E. Co., and experience with steam locomotive mfg co. Desires position with util or mfg co. Location and salary immaterial. Good references. Available immediately. D-2434

B.S. in E.E., 1933, Univ of New Hamp, 21, single. Active in many campus organizations. Good references. Desires position in any elec field. Salary secondary. Location immaterial. D-2433

Maintenance and Operation

E.E. 28, married; grad Pratt Inst '26; 3 yrs experience sub and pwr station operation and maintenance; 4 yrs experience installing and maintaining sound reproduction equip (theatrical); 2 yrs elec repair and test work. Desirous connecting with util, contracting, mfg corp, or other elec opening. Location immaterial. Moderate remuneration. Available immediately. C-3909

E.E., univ grad. Eighteen yrs with pwr cos and affiliated cos, 5 yrs in charge of E.E. dept, desires position as supt of operation or maintenance with pwr co or large pwr user. Temporary position considered. B-1923

Production

PRODUCTION EXEC, 36, single, 15 yrs experience in production of elec equip; also mfg and engg administration. Available immediately. Location in East preferred. D-2445

Research

RESEARCH ENGR, 27, B.S. in E.E., M.A. in physics, 3 yrs B.T. Lab on tube modulation and amplifier design. One yr adv study. Broad exper. and adaptable. Available now for research, design or teaching. D-1233

Sales

SALESMAN, contact repr or mfrs agt, experienced E.E. representative, desires position with high grade co that manufactures a line of high or low voltage apparatus for util or industrial plants. Eastern location preferred. B-4067

SALES ENGR, 9 yrs util engg and operating, 7 yrs techn sales, well acquainted with util engrs in West and Mexico. Desires connection in field with elec mfr. Prepared to offer high class, active representation. D-2388

ENGG SALES WORK DESIRED. B.S. in E.E., 1930, Master of Business Administration, 1933, Univ of Kan. Single, 25. Experience includes 1 yr on G.E. test course and summer work with a util. D-2439

E.E. GRAD, 26, married, desires position in sales or adv dept of an elec mfg co or a utility. One yr in elec dept of steel plant. Seven mos with pwr co. Two summers in sales. Location immaterial. Available on 1 week's notice. Now employed. D-2431

Membership

Recommended for Transfer

The board of examiners, at its meeting of July 27, 1933, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Demarest, Charles S., toll equipment engr., American Tel. & Tel. Co., New York.

To Grade of Member

Borgeson, Carl A., dist. plant engr., Am. Tel. & Tel. Co., N. Y. City.
Bowie, Augustus J., mgr., Bowie Switch Co., San Francisco, Calif.
Burkhardt, Christian E., sub-dist. mgr., Florida Pwr. Corp., Trenton, Fla.
Caldwell, Eugene, gen. mgr., Wrought Washer Mfg. Co., Milwaukee, Wis.
Cerf, Edgar A., Jr., junior engr., Bklyn. Edison Co., Inc., Bklyn., N. Y.
Cobban, Rollo J., sales engr., Westinghouse Elec. & Mfg. Co., San Francisco, Calif.
Dodds, John M., office engr., Gen. Elec. Co., San Francisco, Calif.
Gamble, William H., asst. prof. of E.E., So. Dak. State Col., Brookings, S. D.
Johnston, William S., E.E., Union Oil Co. of Calif., Los Angeles, Calif.
Lawton, Harvey B., director of E.E., Williams Oil-O-Matic Heating Corp., Bloomington, Ill.
Levin, Samuel A., E.E., Bell Tel. Labs., Inc., N. Y. City.
Marshall, Donald E., research engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Meserve, Wilbur E., instructor in E.E., Cornell Univ., Ithaca, N. Y.
Miller, Jesse E., gen. foreman, T. M. E. R. & L. Co., Milwaukee, Wis.
Walther, Lee, research engr., Intl. Business Machines Corp., N. Y. City.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before September 30, 1933, or November 30, 1933, if the applicant resides outside of the United States or Canada.

Bach, W. Jr., Fischbach & Moore, Inc., Washington, D. C.
Back, L. B., 2521 Brookfield Ave., Baltimore, Md.
Beauchemin, J. O., Shawinigan Water and Power Co., Thetford Mines, Que., Can.
Dodge, H. W., N. J. Bell Tel. Co., Trenton, N. J.
Eastman, L. J., So. Sierras Pwr. Co., Riverside, Calif.
Gould, I. J., The Crosbie Co., Washington, D. C.
Grady, R. E. (Member), Pacific Gas & Elec. Co., San Francisco, Calif.
Hutton, W. S., Canadian Fire Underwriters Assn., Toronto, Ont., Can.
Klekotka, F. X., c/o A. H. Hoffman, Inc., Landisville, Pa.
Lanken, N. F., Driver-Harris Wire Co., Harrison, N. J.
McNeill, W. M., Carolina Pwr. & Lt. Co., Pee Dee, N. C.
Miller, H. G., Radio Inventions, Inc., N. Y. City.
Munkasy, P. F., 1144 State St., Bridgeport, Conn.
Newman, W. C. (Member), 1309 Oliver Bldg., E. Pittsburgh, Pa.
Reese, T. L., Vacuum Oil Co., Inc., Olean, N. Y.
Robey, F. C. (Member), Southwestern Bell Tel. Co., Okla. City, Okla.
Thomason, J. L., Gen. Elec. Co., Pittsfield, Mass.
Van Law, T. L., Southern Calif. Edison Co., Ltd., Big Creek, Calif.
Woth, T. J., Westinghouse Elec. & Mfg. Co., N. Y. City.
Zimmerman, J. A., New Martinsville Municipal Utilities, New Martinsville, W. Va.

20 Domestic

Foreign

Kauramalani, M. V., G. I. P. Ry., Matunga, Bombay, India.
Potter-Hanwell, W. S. (Member), Irrigation Dept., Egyptian Govt., Khartoum, Sudan, Africa.
Pujara, M. W., Pub. Works Dept., Fort Bombay, India.
Saini, G. S., Jai-Lakshmi Sugar Co., Ltd., Doiwala (Dehradun) U. P., India.

4 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Blackhall, Harold J., Postlagernd, Essen, Germany
Bugnion, Frank E., 14 Clinton St., Cambridge, Mass.
Collins, H. Stanley, 100 Carlson Road, Rochester, N. Y.
Endicott, E. M., 2020 Monroe St., Toledo, Ohio.
Hottle, Warren M., 437 Hansberry St., Phila., Pa.
Ingles, J. A., c/o Trans. Dept., H. E. P. C., MacLean Bldg., Toronto, Ont., Can.
Jones, Edgar A., 2590—35th St., Astoria, L. I., N. Y.
Kresser, Jeav V., 1106 Bush St., Apt. 407, San Francisco, Calif.
Kubota, K., c/o Japanese Assn. of N. Y., 1819 Broadway, New York City.
Moore, Everett, 2479 Kalakawa Ave., Honolulu, T. H.
Mowat, George, 230 Mather St., Oakland, Calif.
Pedersen, P. R., c/o Sanderson & Porter, 52 William St., New York City.
Perkins, T. S., 154 Maple St., Springfield, Mass.
Stewart, Jenner M., Gen. Del., Jackson, Miss.
Walters, Louis G., c/o Y. M. C. A., Portland, Ore.
Wood, Harry P., 7631 Coles Ave., Chicago, Ill.

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during July are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

ELEKTROTECHNISCHE GESELLSCHAFT 1881–1931. GESCHICHTSTAFELN der ELEKTROTECHNIK. By S. Ruppel. Berlin-Charlottenburg, Verband Deutscher Elektrotechniker, 1932. 127 p., illus., 12x9 in., paper, no price given. Issued by the Frankfurt Society of Electrical Engineers to mark its 50th anniversary. Historical tables present chronologically the important steps in the development of electricity and its applications, and of the development of the principal electrical machines and instruments.

ELEMENTS of ENGINEERING THERMODYNAMICS. By J. A. Moyer, J. P. Calderwood and A. A. Potter. 5 ed. N. Y., John Wiley & Sons, 1933. 192 p., illus., 9x6 in., cloth, $2.50. Presents the fundamental principles of engineering thermodynamics as a foundation for the more advanced and practical applications of the theory. The new material includes the thermodynamic treatment of uniform flow processes and new vapor tables for steam and ammonia. Additional attention is given to reversible and irreversible processes, and standard symbols have been adopted.

From PLAN to REALITY. N. Y., Regional Plan Assn., 1933. 142 p., illus., 11x9 in., cloth, $2.00. Supplements the study of communication facilities and land uses which was published by the regional plan association in 1929, by describing the development of the metropolitan region during the intervening 4 years. Changes in highways, railroads and ports, park extensions, airport and rebuilding projects and advances in planning are set forth, and their relation to the regional plan discussed. Present needs are considered.

HENLEY'S TWENTIETH CENTURY FORMULAS, RECIPES and PROCESSES. Ed. by G. D. Hiscox. rev. ed. N. Y., Norman W. Henley Pub. Co., 1933. 809 p., illus., 9x6 in., cloth, $4.00. A collection of several thousand recipes relating to various trades and handicrafts, which has long been a popular reference book in workshops and homes. The new edition has been revised and modernized.

LABOR ECONOMICS and LABOR PROBLEMS. By D. Yoder. N. Y. & Lond., McGraw-Hill Book Co., 1933. 630 p., illus., 9x6 in., cloth, $3.50. Combines an economical and sociological approach to the study of modern labor economics and problems. The major emphasis is on economic principles, but the problems are also considered fully, and recent suggestions for their treatment are evaluated in terms of the principles involved.

Les MACHINES ÉLECTRIQUES et la PRÉDÉTERMINATION de leur PUISSANCE SPÉCIFIQUE MAXIMUM. By J. Rezelman. Paris, Dunod, 1932. 58 p., illus., 10x6 in., paper, 10frs. Discusses the conditions that will produce the maximum "specific" power in electrical machines and applies the process to d-c dynamos, a synchronous motor, alternators, and transformers. The author is chief engineer of the Charleroi Electrical Machine Works.

MIRRORS, PRISMS and LENSES. By J. P. C. Southall. 3 ed. N. Y., Macmillan Co., 1933. 806 p., illus., 8x5 in., cloth, $4.50. Designed as an introduction to the theory of modern optical instruments, this work uses only the simplest mathematical processes, and presents the earlier and more elementary portions of the subject with much detail. This edition has been enlarged by a new chapter on the microscope, chosen as a typical optical instrument, and one in which various subjects having a bearing on the book as a whole are discussed.

MITTEILUNGEN aus den FORSCHUNGSANSTALTEN des GHH-KONZERNS, Bd. 2, Heft 6, May 1933. Berlin, VDI-Verlag. illus., 12x9 in., paper, 4.25 rm. Includes: (1) a report upon the improvement of arc welds by high-grade covered electrodes; (2) a mathematical investigation of the thermal stresses in an endless disk (of importance in connection with electric welding); (3) the results of systematic investigations of the influence of chemical composition and thermal treatment upon the properties of case-hardened castings.

ORES and INDUSTRY in the FAR EAST. By H. Foster Bain. rev. ed. N. Y., Council on Foreign Relations, 1933. 288 p., illus., 9x6 in., cloth, $3.00. This work, first published in 1927, gives a compact, comprehensive picture of the mineral resources of the Far East, based upon field investigations by the author and others. The new edition has been revised extensively. Figures of production and reserves have been brought down to date when possible, and a chapter added upon the mineral resources of Manchuria and Jehol.

PHYSICAL MECHANICS. By R. B. Lindsay. N. Y., D. Van Nostrand Co., 1933. 436 p., illus., 9x6 in., cloth, $4.00. An intermediate text suitable for students who have had a year of general physics and a 2-year course in general college mathematics. It endeavors to emphasize the fundamentals which are of supreme importance throughout all physics, pure and applied. Many problems are included.

PRINCIPLES of MECHANISM. By A. Vallance and M. E. Farris. N. Y., Macmillan Co., 1933. 335 p., illus., 9x6 in., cloth, $3.50. A compact textbook intended for students of engineering and adapted to courses of from 2 to 4 semester hours. Aims to develop logically the fundamentals of mechanism and to correlate them with the student's work in mathematics and physics, as a foundation for advanced courses in machine design.

SPARKS from the ELECTRODE. (Century of Progress Series.) By C. L. Mantell. Baltimore, Williams & Wilkins Co., 1933. 127 p., illus., 8x5 in., cloth, $1.00. For the non-technical reader who is interested in the industrial achievements of electrochemistry and the part that the electrochemical industries play in our national life. The story is told briefly.

STANDARDS and SPECIFICATIONS for METALS and METAL PRODUCTS. Miscellaneous Publication No. 120. Washington, D. C., U.S. Bureau of Standards, 1933. 1,359 p., illus., 11x8 in., cloth, $3.00. Reproduces the substance and form of over 1,600 specifications, standards and methods of testing which have been prepared by organizations authorized to speak for industry or the Federal Government. These cover ferrous and non-ferrous metals and manufactures, except machinery, vehicles, and electrical supplies. The work of some 80 organizations is combined in one convenient work, with cross references and indexes, and with many illustrations.

STOP THAT SMOKE! By H. Obermeyer, N. Y. & Lond., Harper & Bros., 1933. 289 p., illus., 9x6 in., cloth, $2.50. A popular, non-technical discussion of the smoke nuisance and of means for its abatement, considered from the points of view of health, civic beauty, property damage, and fuel economy. The methods of education, legislation, and regulation which have been used are described. The book affords an excellent review of the methods adopted in American cities and the results achieved.

VORSCHRIFTENBUCH des VERBANDES DEUTSCHER ELEKTROTECHNIKER, 19th ed. Berlin, Verband Deutscher Elektrotechniker, 1933. 1271 p., illus., 9x6 in., cloth, 16.20 rm. Contains the standards, specifications and tests of the Society of German Electrical Engineers, as in force on January 1, 1933. The standards are classified in groups and an extremely detailed index is provided.

ACOUSTICS AND ARCHITECTURE. By P. E. Sabine. Lond. and N. Y., McGraw-Hill Book Co., 1932. 327 p., illus., 9x6 in., cloth, $3.50. Discusses such subjects as reverberation, arthitectural acoustics, sound transmission and absorption, machine isolation and the control of noise in buildings. The principles underlying sound control are discussed and the results of much research work, especially that carried on by the Riverbank Laboratories, are presented.

DARSTELLENDE GEOMETRIE, Pt. 4. (Sammlung Göschen 1063). By R. Haussner and W. Haack. Berlin & Leipzig, Walter de Gruyter & Co., 1933. 144 p., diagrs., 6x4 in., cloth, 1.62 rm. The final volume of this brief text on descriptive geometry is chiefly devoted to perspective and its applications in drawing and mapping. Free perspective, applied perspective, photogrammetry and contouring are described.

NUMBER, the Language of Science. By T. Dantzig, 2 ed. N. Y., Macmillan Co., 1933. 262 p., illus., 9x6 in., cloth, $2.50. An account, intended for readers without a mathematical education, of the manner in which our concept of number has developed from finger counting into a science. Mathematical technicalities have been avoided, and the intelligent layman can follow the intricate story.

AIRCRAFT and the LAW. By H. L. Brown. N. Y., R. O. Ballou, 1933. 359 p., 9x6 in., cloth, $3.00. The reader without legal training will find here an account of the law relating to aircraft, in every day language. The rights, liabilities and duties of those who operate and use aircraft, as they have been determined by regulations and litigation, are covered at length.

ANNUAL SURVEY of AMERICAN CHEMISTRY, v. 7, 1932. Ed. by C. J. West. Publ. for Nat. Research Council by the Chem. Cat. Co., N. Y., 1933. 346 p., diagrs., 9x5 in., cloth, $4.00. This volume gives a concise, accurate account of recent advances in pure and applied chemistry in this country. Each of the 27 monographs is the work of a specialist and is accompanied by exact references to the original publications. Good indexes are provided.

COST ACCOUNTING, Principles and Methods. By C. Reitell. Scranton, Pa., Intl. Textbook Co., 1933. 441 p., illus., 10x6 in., cloth, $3.50. In this new text there is, in addition to established principles and procedures, consideration of the use of cost accounting to measure and evaluate plant performance, the treatment of over-head expense as an item to be controlled rigidly and kept in definite relation to production, and the stressing of managerial foremanship.

ELECTRICAL ENGINEERING CATALOGS. 1932/1933. McGraw-Hill Cat. and Directory Co., N. Y., 1933. 368 p., illus., 11x8 in., cloth, $15.00. Contains a directory of equipment and supplies used in generating, transmitting, and utilizing electric power, with the names of their manufacturers and, in many cases, catalogs of these manufacturers. The book is conveniently arranged and removes the need of maintaining a file of separate catalogs.

Die ELEKTRISCHE WARMBEHANDLUNG in der INDUSTRIE. By E. F. Russ. Munich & Berlin, R. Oldenbourg, 1933. 259 p., illus., 10x7 in., cloth, 14 rm. A volume upon heating furnaces and their applications for heating, drying, enameling, tempering, annealing, etc. The fields to which electric heating is adapted are first described after which the general construction of the electric furnace is treated. Describes a large variety of furnaces for special purposes.

ELEMENTARY STEAM POWER ENGINEERING. By E. MacNaughton. 2 ed. N. Y., John Wiley & Sons, 1933. 649 p., illus., 9x6 in., cloth, $5.00. Aims to discuss clearly and concisely the fundamenal principles underlying the construction and operation of the equipment of the steam power plant. Uses but a minimum of mathematics; practical phases of each topic are described before the theory is considered.

ELEMENTS of POWER GENERATION. By A. M. Greene, Jr. N. Y., John Wiley & Sons, 1933. 314 p., illus., 9x6 in., cloth, $3.25. Intended to give the young engineering student and the general reader an appreciation of the various ways in which power is obtained from natural sources. Describes the principles, limitations, and operation of the equipment of the modern power station. The treatment is descriptive. Little theoretical matter is included.

Engineering Societies Library

29 West 39th Street, New York, N.Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Officers and Committees for 1933-34

President

J. B. WHITEHEAD — Baltimore, Md.
(*Term expires July 31, 1934*)

Junior Past-Presidents

C. E. SKINNER — Wilkinsburg, Pa.
(*Term expires July 31, 1934*)
H. P. CHARLESWORTH — New York, N. Y.
(*Term expires July 31, 1935*)

Vice-Presidents

Dist. No.		
(1)	J. ALLEN JOHNSON	Buffalo, N. Y.
(3)	E. B. MEYER	Newark, N. J.
(5)	K. A. AUTY	Chicago, Ill.
(7)	STANLEY STOKES	St. Louis, Mo.
(9)	C. R. HIGSON	Salt Lake City, Utah
		(*Terms expire July 31, 1934*)
(2)	A. M. WILSON	Cincinnati, Ohio
(4)	F. M. CRAFT	Atlanta, Ga.
(6)	R. B. BONNEY	Denver, Colo.
(8)	R. W. SORENSEN	Pasadena, Calif.
(10)	A. H. HULL	Toronto, Canada
		(*Terms expire July 31, 1935*)

Directors

A. B. COOPER — Toronto, Canada
A. E. KNOWLTON — New York, N. Y.
R. H. TAPSCOTT — New York, N. Y.
(*Terms expire July 31, 1934*)

L. W. CHUBB — East Pittsburgh, Pa.
B. D. HULL — Dallas, Tex.
H. R. WOODROW — Brooklyn, N. Y.
(*Terms expire July 31, 1935*)

G. A. KOSITZKY — Cleveland, Ohio
A. H. LOVELL — Ann Arbor, Mich.
A. C. STEVENS — Schenectady, N. Y.
(*Terms expire July 31, 1936*)

P. B. JUHNKE — Chicago, Ill.
EVERETT S. LEE — Schenectady, N. Y.
L. W. W. MORROW — New York, N. Y.
(*Terms expire July 31, 1937*)

National Treasurer

W. I. SLICHTER — New York, N. Y.
(*Term expires July 31, 1934*)

National Secretary

H. H. HENLINE — New York, N. Y.
(*Term expires July 31, 1934*)

General Counsel

Parker & Aaron
20 Exchange Place, New York, N. Y.

Local Honorary Secretaries

V. J. F. Brain, Dept. of Pub. Wks., Phillip St., Sydney, N. S. W., Australia.
F. M. Servos, Rio de Janeiro Tramway, Lt. & Pr. Co., Rio de Janeiro, Brazil.
A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.
A. S. Garfield, 173 Blvd. Haussmann, Paris (8e), France.
H. P. Thomas, 41, The Lower Mall, Lahore, India.
Renzo Norsa, Via Caravaggio 1, Milano 25, Italy.
P. H. Powell, Canterbury College, Christchurch, New Zealand.
M. A. Chatelain, Polytechnical Institute, Apt. 27, Leningrad, Sosnowka 1-3, U.S.S.R.
A. F. Enstrom, Ingeniorsvetenskrapsakademien, Stockholm, 5, Sweden.
W. Elsdon-Dew, P. O. Box 4563, Johannesburg, Transvaal, Africa.

GENERAL COMMITTEES

Executive

John B. Whitehead, Chm., Johns Hopkins University, Baltimore, Md.
H. P. Charlesworth — E. B. Meyer
J. Allen Johnson — C. E. Skinner
Everett S. Lee — W. I. Slichter

Coördination of Institute Activities

E. B. Meyer, Chm., 80 Park Place, Newark, N. J.
R. N. Conwell — H. H. Henline
W. S. Gorsuch — I. Melville Stein

Board of Examiners

H. Goodwin, Jr., Chm., H. L. Doherty & Co., 60 Wall St., New York, N. Y.
H. E. Farrer, Secy., 33 W. 39th St., New York, N. Y.
H. A. Currie — F. V. Magalhaes
H. C. Dean — R. H. Marriott
H. W. Drake — L. W. W. Morrow
S. P. Grace — A. L. Powell
H. A. Kidder — S. D. Sprong — W. R. Smith

Columbia University Scholarships

W. I. Slichter, Chm., Columbia University, New York, N. Y.
Francis Blossom — H. C. Carpenter

Constitution and By-Laws

W. S. Gorsuch, Chm., 600 West 59th Street, New York, N. Y.
C. O. Bickelhaupt — E. B. Meyer
H. A. Kidder — W. I. Slichter

Economic Status of the Engineer

C. O. Bickelhaupt, Chm., American Tel & Tel. Co., 195 Broadway, New York, N. Y.
A. E. Knowlton — W. S. Rugg
E. W. Rice, Jr. — Charles F. Scott

Edison Medal

Appointed by the President for term of 5 years.
H. B. Gear — L. W. W. Morrow — W. S. Rugg
(*Terms expire July 31, 1934*)
C. I. Burkholder — F. A. Gaby — H. J. Ryan
(*Terms expire July 31, 1935*)
H. H. Barnes, Jr. — E. B. Meyer — P. H. Thomas
(*Terms expire July 31, 1936*)
Gano Dunn — S. P. Grace — C. E. Stephens, Chm.
(*Terms expire July 31, 1937*)
V. Bush — H. P. Charlesworth — K. S. Wyatt
(*Terms expire July 31, 1938*)

Appointed by the Board of Directors from its own membership for term of 2 years.
J. Allen Johnson — A. E. Knowlton — R. H. Tapscott
(*Terms expire July 31, 1934*)
L. W. Chubb — G. A. Kositzky — H. R. Woodrow
(*Terms expire July 31, 1935*)

Ex-officio
John B. Whitehead, President
W. I. Slichter, National Treasurer
H. H. Henline, National Secretary
(*Terms expire July 31, 1934*)

Finance

E. B. Meyer, Chm., 80 Park Place, Newark, N. J.
Everett S. Lee — R. H. Tapscott

Headquarters

W. S. Gorsuch, Chm., 600 West 59th Street, New York, N. Y.
H. H. Henline — E. B. Meyer

Institute Policy

H. P. Charlesworth, Chm., 195 Broadway, New York, N. Y.
C. C. Chesney — Wm. McClellan
B. Gherardi — E. L. Moreland
W. S. Lee — C. E. Skinner — Farley Osgood

Iwadare Foundation

F. B. Jewett, Chm.,195 Broadway, New York, N. Y.
C. E. Skinner — Gerard Swope

Lamme Medal

A. M. Dudley — P. M. Lincoln — J. C. Parker
(*Terms expire July 31, 1934*)
P. L. Alger — H. B. Gear — C. E. Skinner, Chm.
(*Terms expire July 31, 1935*)
C. F. Harding — Malcolm MacLaren — R. W. Sorensen
(*Terms expire July 31, 1936*)

Legislation Affecting the Engineering Profession

W. I. Slichter, Chm., Columbia University, New York, N. Y.
James P. Alexander — John C. Parker
T. F. Barton — John R. Price
B. M. Brigman — Lester S. Ready
W. H. Harrison — Herbert S. Sands
D. C. Jackson — M. R. Scharff
L. W. W. Morrow — J. B. Thomas — H. H. Schoolfield

Membership

Everett S. Lee, Chm., General Electric Co., Schenectady, N. Y.
R. W. Adams — J. Allen Johnson
L. A. Bingham — R. L. Kirk
E. P. Coles — J. H. Lampe
E. S. Fields — T. G. LeClair
F. G. Graf — E. F. Pearson
S. E. M. Henderson — W. B. Stephenson
H. W. Hitchcock — Stanley Stokes
Ex-officio
Chairmen of Section membership committees.

New York Museum of Science and Industry, Advisory Committee to

John Price Jackson, Chm., New York Edison Company, 130 E. 15th Street, New York, N. Y.
C. O. Bickelhaupt — R. H. Nexsen

Popular Science Award

Harold Pender, Chm., University of Pennsylvania, Philadelphia, Pa.
W. H. Harrison — C. H. Willis

Principles of Professional Conduct Code of

C. E. Stephens, Chm., Westinghouse Elec. & Mfg. Co., 150 Broadway, New York, N. Y.
A. H. Babcock — F. B. Jewett
L. W. Chubb — W. S. Lee
G. Faccioli — W. E. Mitchell

Prizes, Award of Institute

R. N. Conwell, Chm., 80 Park Place, Newark, N. J.
W. H. Harrison — E. B. Meyer — Chester W. Rice

Publication

E. B. Meyer, Chm., 80 Park Place, Newark, N. J.
F. A. Lewis, Secy., 33 W. 39th St., New York, N. Y.
R. N. Conwell — H. H. Henline
W. S. Gorsuch — H. R. Woodrow

Safety Codes

F. V. Magalhaes, Chm., General Electric Company, 40 Federal Street, West Lynn, Mass.
J. C. Balsbaugh — A. E. Knowlton
A. W. Berresford — W. B. Kouwenhoven
George S. Diehl — M. G. Lloyd
J. F. Fairman — Wills Maclachlan
H. B. Gear — John D. Noyes
I. W. Gross — F. A. Pattison
F. D. Knight — H. S. Warren — Frank Thornton, Jr.

Sections

I. Melville Stein, Chm., Leeds & Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.
L. A. Doggett — G. H. Quermann
W. B. Kouwenhoven — J. J. Shoemaker
Everett S. Lee — W. H. Timbie
Ex-officio
Chairmen of all Sections of the Institute.

Standards

A. M. MacCutcheon, Chm., 1088 Ivanhoe Road, Cleveland, Ohio
H. E. Farrer, Secy., 33 W. 39th St., New York, N. Y.
A. B. Cooper — V. M. Montsinger
J. E. Goodale — F. D. Newbury
G. R. Harte — E. B. Paxton
J. Franklin Meyer — W. I. Slichter
Ex-officio
Chairmen of working committees.
Chairmen of A.I.E.E. delegations and representatives on other standardizing bodies.
President of U.S. national committee of I.E.C.

Student Branches

L. A. Doggett, Chm., Pennsylvania State College, State College, Pa.
R. B. Bonney — Charles F. Scott
F. O. McMillan — W. H. Timbie
Ex-officio
Student Branch Counselors.

Transfers

J. Allen Johnson, Chm., 302 Electric Building, Buffalo, N. Y.
H. Goodwin, Jr. — E. B. Meyer — Charles F. Scott

Technical Program

R. N. Conwell, Chm., 80 Park Place, Newark, N. J.
C. S. Rich, Secy., 33 W. 39th St., New York, N. Y.
J. W. Barker, W. S. Gorsuch, H. S. Bennion, F. C. Hanker, O. G. C. Dahl, W. H. Harrison, H. B. Gear, W. B. Kouwenhoven, B. D. Hull

Ex-officio

Chairman of committee on coördination of Institute activities.
Chairmen of technical committees.

TECHNICAL COMMITTEES

Automatic Stations

D. W. Taylor, Chm., United Engineers & Constructors, Inc., 80 Park Place, Newark, N. J.
F. F. Ambuhl, I. E. Moultrop, A. E. Anderson, M. E. Reagan, L. D. Bale, O. J. Rotty, John Fies, Garland Stamper, A. M. Garrett, L. J. Turley, Joseph Hellenthal, Chester Wallace, C. R. Higson, F. Zogbaum

Communication

H. S. Osborne, Chm., 195 Broadway, New York, N. Y.
H. M. Bascom, G. M. Keenan, Edward L. Bowles, G. A. Kositzky, A. A. Clokey, C. J. Larsen, J. O'R. Coleman, J. R. MacGregor, F. M. Craft, John Mills, R. D. Evans, J. W. Milnor, W. L. Everitt, C. W. Mitchell, I. C. Forshee, E. J. O'Connell, G. H. Gray, J. J. Pilliod, H. H. Haglund, F. H. Pumphrey, H. A. Haugh, Jr., E. R. Shute, H. L. Huber, A. L. Stadermann, B. D. Hull, C. H. Taylor, C. M. Jansky, Jr., H. M. Turner, T. Johnson, Jr., F. A. Wolff, R. S. Wishart

Education

L. A. Doggett, Chm., Pennsylvania State College, State College, Pa.
J. W. Barker, D. C. Jackson, Jr., Edward Bennett, Francis E. Johnson, P. S. Biegler, C. L. Kinsloe, R. B. Bonney, A. H. Lovell, E. L. Bowles, Wm. B. Potter, H. V. Carpenter, Burke Smith, R. E. Doherty, A. C. Stevens, A. M. Dudley, G. B. Thomas, O. W Eshbach, W. L. Upson, H. H. Henline, Joseph Weil

Electric Welding

K. L. Hansen, Chm., 2916 N. Prospect Ave., Milwaukee, Wis.
C. A. Adams, J. C. Lincoln, J. H. Blankenbuehler, Ernest Lunn, A. M. Candy, C. L. Pfeiffer, F. Creedy, J. Slepian, S. Dushman, Wm. Spraragen, D. D. Ewing, A. C. Stevens, H. M. Hobart, H. E. Stoddard, R. G. Hudson, H. W. Tobey

Electrical Machinery

S. L. Henderson, Chm., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
P. L. Alger, H. C. Louis, B. L. Barns, W. V. Lyon, E. S. Bundy, A. M. MacCutcheon, A. B. Cooper, V. M. Montsinger, H. E. Edgerton, S. H. Mortensen, Ralph Ehrenfeld, R. W. Owens, J. L. Hamilton, E. B. Paxton, A. L. Harding, H. V. Putman, J. Allen Johnson, K. A. Reed, J. J. Linebaugh, O. E. Shirley

Instruments and Measurements

W. B. Kouwenhoven, Chm., Johns Hopkins University, Baltimore, Md.
H. S. Baker, O. A. Knopp, R. D. Bean, A. E. Knowlton, O. J. Bliss, H. C. Koenig, Perry A. Borden, Everett S. Lee, H. B. Brooks, J. B. Lunsford, A. L. Cook, Paul MacGahan, J. S. Cruikshank, R. T. Pierce, E. D. Doyle, E. J. Rutan, Marion Eppley, A. C. Seletzky, W. N. Goodwin, Jr., Harry L. Thomson, T. S. Gray, H. M. Turner, I. F. Kinnard, Joseph Weil

Electrochemistry and Electrometallurgy

Warren C. Kalb, Chm., National Carbon Co., Cleveland, Ohio
J. C. Hale, Secy.
A. E. Knowlton, J. V. Alfriend, Kenneth L. Scott, P. H. Brace, N. R. Stansel, F. M. Clark, Magnus Unger, G. W. Elmen, H. B. Vidal, A. M. Hamann, George W. Vinal, H. P. Kirchner, J. L. Woodbridge

Electrophysics

Joseph Slepian, Chm., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
R. C. Mason, Secy.
S. S. Attwood, R. D. Fay, A. Boyajian, C. S. Gordon, O. E. Buckley, L. O. Grondahl, K. K. Darrow, H. H. Race, W. F. Davidson, J. B. Whitehead, M. S. Vallarta

Iron and Steel Production, Applications to

F. O. Schnure, Chm., Bethlehem Steel Co., Sparrows Point, Md.
K. A. Auty, A. F. Kenyon, J. J. Booth, John S. Murray, F. B. Crosby, Wilfred Sykes, Wray Dudley, R. H. Wright, H. A. Winne

Light, Production and Application of

J. W. Barker, Chm., Columbia University, New York, N. Y.
S. K. Barrett, W. C. Kalb, Robin Beach, R. D. Mailey, W. T. Blackwell, George S. Merrill, H. S. Broadbent, P. S. Millar, W. T. Dempsey, L. W. W. Morrow, H. W. DeSaix, C. McL. Moss, E. E. Dorting, F. R. Nugent, C. A. B. Halvorson, A. L. Powell, L. A. Hawkins, R. E. Simpson, J. T. Holmes, Philip Sporn, H. E. Ives, C. J. Stahl

Marine Work, Applications to

H. C. Coleman, Chm., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
E. C. Alger, L. W. W. Morrow, R. A. Beekman, I. H. Osborne, E. M. Glasgow, G. A. Pierce, H. F. Harvey, Jr., Wm. H. Reed, C. J. Henschel, H. M. Southgate, Wm. Hetherington, Jr., Walter E. Thau, H. L. Hibbard, A. E. Waller, J. E. Kearns, Oscar A. Wilde, A. Kennedy, Jr., J. L. Wilson, J. B. Lunsford, W. N. Zippler, R. L. Witham

Mining Work, Applications to

E. B. Wagner, Chm., Lehigh Valley Coal Co., Wilkes-Barre, Pa.
J. E. Borland, Carl Lee, Graham Bright, W. H. Lesser, John H. Edwards, C. W. Parkhurst, C. R. Higson, D. E. Renshaw, L. C. Ilsley, F. L. Stone, Luther H. James, C. D. Woodward, J. F. Wiggert

Power Applications, General

M. R. Woodward, Chm., Babcock & Wilcox Co., 20 N. Wacker Drive, Chicago, Ill.
A. H. Albrecht, A. E. Knowlton, E. A. Armstrong, H. A. Maxfield, James Clark, Jr., John Morse, L. M. Dawes, N. L. Mortensen, C. W. Drake, D. M. Petty, J. F. Gaskill, H. W. Rogers, John Grotzinger, L. D. Rowell, T. Hibbard, L. M. Shadgett, Fraser Jeffrey, W. K. Vanderpoel

Protective Devices

R. T. Henry, Chm., Buffalo, Niagara & Eastern Power Corp., Electric Building, Buffalo, N. Y.
J. C. Balsbaugh, H. A. McLaughlin, H. W. Collins, K. K. Palueff, W. S. Edsall, D. M. Petty, J. H. Foote, C. H. Sanderson, S. L. Goldsborough, H. J. Scholz, S. M. Hamill, Jr., H. K. Sels, Joseph Hellenthal, H. P. Sleeper, A. V. Joslin, L. G. Smith, T. G. LeClair, Stanley Stokes, W. A. Lewis, Jr., H. R. Summerhayes, H. J. Lingal, B. F. Thomas, Jr., K. B. McEachron, O. C. Traver, J. P. McKearin, H. B. Wood, E. M. Wood

Power Generation

H. W. Leitch, Chm., United Elec. Lt. & Pwr. Co., 130 E. 15th St., New York, N. Y.
F. A. Annett, A. H. Lovell, J. R. Baker, I. E. Moultrop, A. E. Bauhan, A. L. Penniman, Jr., J. B. Crane, G. G. Post, W. S. Gorsuch, C. A. Powel, P. H. Chase, F. A. Scheffler, F. H. Hollister, A. E. Silver, A. H. Hull, W. F. Sims, A. V. Karpov, Philip Sporn

Power Transmission and Distribution

D. M. Simmons, Chm., General Cable Corp., 420 Lexington Ave., New York, N. Y.
C. T. Sinclair, Vice-Chm.
T. A. Worcester, Secy.
K. A. Hawley, L. F. Hickernell, F. E. Andrews, C. R. Higson, G. M. Armbrust, W. A. Hillebrand, Raymond Bailey, D. C. Jackson, Jr., D. K. Blake, J. P. Jollyman, M. O. Bolser, P. B. Juhnke, E. S. Bundy, A. H. Lawton, A. B. Campbell, J. B. MacNeill, C. V. Christie, L. N. McClellan, R. N. Conwell, L. L. Perry, W. A. Curry, D. W. Roper, A. E. Davison, H. J. Scholz, S. M. Dean, G. B. Shanklin, M. Eldredge, A. E. Silver, R. D. Evans, L. G. Smith, F. M. Farmer, H. H. Spencer, C. L. Fortescue, Philip Sporn, C. W. Franklin, Stanley Stokes, T. H. Haines, W. K. Vanderpoel, E. Hansson, H. S. Warren, C. F. Harding, L. F. Woodruff, A. M. Wilson

Research

Chester W. Rice, Chm., General Electric Co., Schenectady, N. Y.
R. W. Atkinson, A. E. Kennelly, L. W. Chubb, W. B. Kouwenhoven, E. H. Colpitts, F. W. Peek, Jr., E. C. Crittenden, Hubert H. Race, O. G. C. Dahl, D. W. Roper, W. F. Davidson, T. Spooner, F. M. Farmer, Philip Sporn, F. Hamburger, Jr., C. H. Willis, V. Karapetoff, R. J. Wiseman

Transportation

E. L. Moreland, Chm., 31 St. James Ave., Boston, Mass.
R. M. Allen, W. A. Giger, H. L. Andrews, John Murphy, K. A. Auty, N. W. Storer, Reinier Beeuwkes, W. M. Vandersluis, H. A. Currie, Sidney Withington, J. V. B. Duer, G. I. Wright

INSTITUTE REPRESENTATIVES

Alfred Noble Prize Committee

W. H. Harrison

Am. Assoc. for the Advt. of Science, Council

C. A. Adams, C. E. Skinner

American Bureau of Welding

H. M. Hobart

American Committee on Marking of Obstructions to Air Navigation

W. H. Harrison

American Engg. Council Assembly

*C. O. Bickelhaupt, L. F. Morehouse, *F. J. Chesterman, I. E. Moultrop, M. M. Fowler, Farley Osgood, H. H. Henline, C. F. Scott, W. S. Lee, *C. E. Skinner, A. M. MacCutcheon, *C. E. Stephens, William McClellan, *J. B. Whitehead, L. B. Stillwell

* *A.I.E.E. representatives on administrative board.*

American Marine Standards Committee

R. A. Beekman

American Stds. Assoc. Bd. of Directors

Bancroft Gherardi

American Stds. Assoc. Council

A. M. MacCutcheon, F. D. Newbury, H. S. Osborne

Alternates

H. H. Henline, E. B. Paxton

American Year Book, Advisory Board
H. H. Henline

Charles A. Coffin Fellowship and Research Fund Committee
J. B. Whitehead

Com. of Apparatus Makers and Users, N.R.C.
L. F. Adams

Com. on Heat Transmission, N.R.C.
T. S. Taylor

Coördination Committee of Engineering Societies
W. A. Del Mar L. B. Stillwell Calvert Townley

Educ. Research Com., The Engg. Foundation
W. S. Rodman

Engineering Foundation Board
C. E. Skinner W. I. Slichter

Engineering Index Advisory Board
H. H. Henline

Engg. Societies Monographs Committee
E. B. Meyer W. I. Slichter

Electrical Standards Committee, A.S.A.
A. M. MacCutcheon H. S. Osborne
F. D. Newbury E. B. Paxton, *Alternate*

Engineers' Council for Professional Development
C. O. Bickelhaupt L. W. W. Morrow C. F. Scott

Hoover Medal Board of Award
Gano Dunn F. B. Jewett E. W. Rice, Jr.

John Fritz Medal Board of Award
H. P. Charlesworth Bancroft Gherardi W. S. Lee
C. E. Skinner

Library Board, United Engg. Trustees, Inc.
W. S. Barstow H. H. Henline
W. A. Del Mar W. I. Slichter W. B. Jackson

Nat. Fire Prot. Assoc. Electrical Committee
F. V. Magalhaes H. S. Warren, *Alternate*

National Fire Waste Council F. V. Magalhaes

Nat. Research Council, Division of Engg. and Industrial Research
H. P. Charlesworth F. B. Jewett
L. W. Chubb Chester W. Rice D. C. Jackson
Ex-officio H. H. Henline

Nat. Safety Council, A.S.S.E.—Engg. Section, Com. on Low Voltage Hazards F. V. Magalhaes

Radio Advisory Com., Bur. of Standards
A. E. Kennelly

Research Procedure Com., Engg. Foundation
L. W. Chubb

United Engineering Trustees, Inc.
H. P. Charlesworth H. A. Kidder G. L. Knight

U.S. National Committee of the International Commission on Illumination
A. E. Kennelly C. F. Scott C. H. Sharp

Commission of Washington Award
L. A. Ferguson Wm. B. Jackson

Geographical District Executive Committees

District	Chairman (Vice-President, A.I.E.E.)	Secretary (District Secretary)
No. 1—North Eastern	J. Allen Johnson, 302 Electric Building, Buffalo, N. Y.	A. C. Stevens, General Electric Co., Schenectady, N. Y.
No. 2—Middle Eastern	A. M. Wilson, University of Cincinnati, Cincinnati, Ohio	L. L. Bosch, Columbia Engg. & Management Corp., 323 Plum St., Cincinnati, Ohio
No. 3—New York City	E. B. Meyer, 80 Park Place, Newark, N. J.	C. R. Jones, Westinghouse E. & M. Co., 150 Broadway, New York, N. Y.
No. 4—Southern	F. M. Craft, P. O. Box 2211, Atlanta, Ga.	S. A. Flemister, P. O. Box 2211, Atlanta, Ga.
No. 5—Great Lakes	K. A. Auty, Commonwealth Edison Co., 72 West Adams St., Chicago, Ill.	A. G. Dewars, No. States Pr. Co., 15 S. 15th St., Minneapolis, Minn.
No. 6—North Central	R. B. Bonney, 1421 Champa St., Denver, Colo.	W. G. Rubel, Mountain States Tel. & Tel. Co., 931 Fourteenth St., Denver, Colo.
No. 7—South West	Stanley Stokes, Union Elec. Lt. & Pr. Co., 12th & Locust Sts., St. Louis, Mo.	H. R. Fritz, Southwestern Bell Tel. Co., 1010 Pine St., St. Louis, Mo.
No. 8—Pacific	R. W. Sorensen, California Institute of Technology, Pasadena, Calif.	J. N. Kelman, Kelman Electric & Mfg. Co., 1650 Naud St., Los Angeles, Calif.
No. 9—North West	C. R. Higson, Utah Power & Light Co., Kearns Building, Salt Lake City, Utah	Paul Ransom, Utah Apex Mining Co., Bingham Canyon, Utah
No. 10—Canada	A. H. Hull, Hydro-Elec. Power Commission, 620 University Ave., Toronto, Ont.	W. L. Amos, Hydro-Elec. Pr. Comm., 620 University Ave., Toronto, Ont.

Note: Each district executive committee includes the chairmen and secretaries of all Sections within the district and the chairman of the district committee on student activities.

Local Sections of the Institute

Name	District	Chairman	Secretary	Secretary's Address
Akron	2	P. C. Smith	V. W. Shear	Verne W. Shear & Co., Akron, Ohio
Atlanta	4	D. H. Woodward	J. H. Persons	General Electric Co., Atlanta, Ga.
Baltimore	2	L. G. Smith	J. H. Lampe	Johns Hopkins Univ., Baltimore, Md.
Birmingham	4	W. W. Ballew	H. M. Woodward	Southern Bell Tel. & Tel. Co., Birmingham, Ala.
Boston	1	W. H. Timbie	J. M. Murray	66 Sidney St., Cambridge, Mass.
Chicago	5	E. C. Williams	F. A. Rogers	Lewis Institute, Chicago, Ill.
Cincinnati	2	L. C. Nowland	M. S. Schneider	Union Gas & Elec. Co., Cincinnati, Ohio
Cleveland	2	R. C. Putnam	C. A. Harrington	Cleveland Elec. Ill. Co., Cleveland, Ohio
Columbus	2	H. L. Willson	J. A. Dawson	42 E. Gay St., Columbus, Ohio
Connecticut	1	C. T. Hughes	W. B. Hall	Yale University, New Haven, Conn.
Dallas	7	D. H. Levy	E. T. Gunther	General Cable Corp., 806 Interurban Bldg., Dallas, Texas
Denver	6	A. W. Ainsworth	N. R. Love	807 Tramway Bldg., Denver, Colo.
Detroit-Ann Arbor	5	R. Foulkrod	J. R. North	The Commonwealth & Southern Corp., Jackson, Mich.
Erie	2	W. D. Bearce	F. B. Moore	18 Hess Ave., Erie, Pa.
Florida	4	Joseph Weil	R. P. Smith	P. O. Box 2574, Jacksonville, Fla.
Fort Wayne	5	C. M. Summers	O. Kiltie	General Electric Co., Fort Wayne, Ind.
Houston	7	J. S. Waters	J. B. Burr	General Electric Co., Houston, Texas
Indianapolis-Laf	5	C. E. Chatfield	T. F. Irvine	108 So. Emerson Ave., Indianapolis, Ind.
Iowa	5	E. R. McKee	C. R. Poe	Telephone Bldg., Room 816, Des Moines, Iowa
Ithaca	1	B. K. Northrop	L. A. Burckmyer, Jr.	Cornell University, Ithaca, N. Y.
Kansas City	7	R. W. Warner	A. T. Campbell	Southwestern Bell Tel. Co., Kansas City, Mo.
Lehigh Valley	2	N. S. Hibshman	W. A. Skinner	Penn. Pwr. & Lt. Co., 117 E. Broad St., Hazleton, Pa.
Los Angeles	8	A. P. Hill	Fred Garrison	5201 Santa Fe Ave., Los Angeles, Calif.
Louisville	4	S. T. Fife	W. H. Mansfield	Southern Bell Tel. Co., Louisville, Ky.
Lynn	1	S. A. Moss	H. A. Hemingway	General Electric Co., Lynn, Mass.
Madison	5	T. A. Brown	R. E. Johnson	University of Wisconsin, Madison, Wis.
Memphis	4	G. O. MacFarlane	F. L. Christenbury	Memphis Pwr. & Lt. Co., Memphis, Tenn.
Mexico	3	W. A. Schulenburg	L. Castro, Jr.	Dept. Elec. y Teleg., Ferrocarilles Nacionales de Mex., Mexico, D. F.
Milwaukee	5	K. L. Hansen	J. A. Potts	Milwaukee Elec. Ry. & Lt. Co., Milwaukee, Wis.
Minnesota	5	E. H. Hagensick	P. G. Bowman	General Electric Co., Minneapolis, Minn.
Montana	9	J. A. Thaler	H. Dale Cline	312 So. 6th Ave., Bozeman, Montana
Nebraska	6	H. S. Pahren	T. H. Granfield	1324 Telephone Bldg., Omaha, Neb.
New York	3	C. R. Jones	C. R. Beardsley	Brooklyn Edison Co., 380 Pearl St., Brooklyn, N. Y.
Niagara Frontier	1	J. S. Henderson	J. F. Oehler	169 Brunswick Blvd., Buffalo, N. Y.
North Carolina	4	F. L. Moser	G. F. Stratton	Box 218, Charlotte, N. C.
Oklahoma City	7	R. F. Danner	C. E. Bathe	Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Philadelphia	2	P. S. Harkins	J. L. MacBurney	Elec. Storage Battery Co., Philadelphia, Pa.
Pittsburgh	2	R. L. Kirk	H. A. P. Langstaff	West Penn Pwr. Co., 14 Wood St., Pittsburgh, Pa.

Name	District	Chairman	Secretary	Secretary's Address
Pittsfield	1	W. H. Cooney	C. A. Read	General Electric Co., Pittsfield, Mass.
Portland, Ore.	9	V. B. Wilfley	Walter Brenton	Portland General Electric Co., Portland, Ore.
Providence	1	O. W. Briden	R. W. Allen	Narragansett Elec. Co., Providence, R. I.
Rochester	1	E. G. Eidam	Wm. M. Young	Taylor Instrument Co., Rochester, N. Y.
St. Louis	7	L. S. Washington	B. F. Thomas, Jr	2183 Rwy. Exch. Bldg., St. Louis, Mo.
San Antonio	7	V. H. Braunig	R. J. Foley	San Antonio Pub. Serv. Co., San Antonio, Texas
San Francisco	8	W. C. Smith	E. M. Wright	245 Market St., San Francisco, Calif.
Saskatchewan	10		R. W. Jickling	Sask. Pwr. Co., 1739 Cornwall St., Regina, Sask.
Schenectady	1	D. W. McLenegan	H. H. Race	General Electric Co., Schenectady, N. Y.
Seattle	9	G. L. Hoard	E. L. White	Puget Sound Pwr. & Lt. Co., Electric Bldg., Seattle, Wash.
Sharon	2	W. W. Satterlee	F. J. Vogel	Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Southern Virginia	4	J. T. Graff	E. L. Lockwood	Virginia Pub. Serv. Co., Newport News, Va.
Spokane	9	W. M. Allen	C. E. Cannon	Washington Water Pwr. Co., Spokane, Wash.
Springfield, Mass	1	L. C. Packer	J. J. Finn	Roland T. Oakes Co., Holyoke, Mass.
Syracuse	1	W. E. Mueller	G. E. Tennent	210 Crippan Ave., Syracuse, N. Y.
Toledo	2	E. H. Howell	W. M. Campbell	Toledo Edison Co., Toledo, Ohio
Toronto	10	G. D. Floyd	J. M. Thomson	171 John St., Weston, Toronto, Ont., Can.
Urbana	5	H. N. Hayward	H. A. Brown	Univ. of Illinois, Urbana, Ill.
Utah	9	E. L. Morris	W. M. Scott	Utah Pwr. & Lt. Co., Salt Lake City, Utah
Vancouver	10	L. B. Stacey	D. M. Johnstone	B. C. Elec. Ry. Co. Ltd., Vancouver, B. C., Can.
Washington	2	R. Whitehurst	G. G. Coleman	Chesapeake & Potomac Tel. Co., Washington, D. C.
Worcester	1	L. S. Leavitt	R. P. Bullen	General Electric Co., Worcester, Mass.
Total 60				

Student Branches of the Institute

Name and Location	District	Counselor
Akron, Univ. of, Akron, Ohio	2	J. T. Walther
Alabama Poly. Inst., Auburn, Ala	4	W. W. Hill
Alabama, Univ. of, University, Ala	4	Fred R. Maxwell, Jr.
Arizona, Univ. of, Tucson, Ariz	8	J. C. Clark
Arkansas, Univ. of, Fayetteville, Ark	7	W. B. Stelzner
Armour Inst. of Tech., Chicago, Ill	5	E. H. Freeman
British Col., Univ. of, Vancouver, B. C	10	E. G. Cullwick
Brooklyn, Poly. Inst. of, Brooklyn, N. Y	3	C. C. Whipple
Bucknell Univ., Lewisburg, Pa	2	G. A. Irland
Calif. Inst. of Tech., Pasadena, Calif	8	F. C. Lindvall
Calif., Univ. of, Berkeley, Calif	8	W. A. Hillebrand
Carnegie Inst. of Tech., Pittsburgh, Pa	2	G. McC. Porter
Case Sch. of Ap. Science, Cleveland, Ohio	2	H. B. Dates
Catholic Univ. of America, Washington, D. C	2	T. J. MacKavanagh
Cincinnati, Univ. of, Cincinnati, Ohio	2	L. R. Culver
Clarkson College of Tech., Potsdam, N. Y	1	Alfred R. Powers
Clemson Agri. Col., Clemson College, S. C	4	S. R. Rhodes
Colorado State Agri. Col., Ft. Collins, Colo	6	H. G. Jordan
Colorado, Univ. of, Boulder, Colo	6	W. C. DuVall
Cooper Union, New York, N. Y	3	A. J. B. Fairburn
Cornell University, Ithaca, N. Y	1	E. M. Strong
Denver, Univ. of, Denver, Colo	6	R. E. Nyswander
Detroit, Univ. of, Detroit, Mich	5	H. O. Warner
Drexel Inst., Philadelphia, Pa	2	E. O. Lange
Duke Univ., Durham, N. C	4	W. J. Seeley
Florida, Univ. of, Gainesville, Fla	4	Joseph Weil
George Washington Univ., Washington, D. C	2	Alfred Ennis
Georgia School of Tech., Atlanta, Ga	4	T. W. Fitzgerald
Harvard Univ., Cambridge, Mass	1	Chester L. Dawes
Idaho, Univ. of, Moscow, Idaho	9	J. H. Johnson
Illinois, Univ. of, Urbana, Ill	5	C. E. Skroder
Iowa State College, Ames, Iowa	5	F. E. Johnson
Iowa, Univ. of, Iowa City, Iowa	5	E. B. Kurtz
Kansas State Col., Manhattan, Kansas	7	R. G. Kloeffler
Kansas, Univ. of, Lawrence, Kansas	7	D. C. Jackson, Jr.
Kentucky, Univ. of, Lexington, Ky	4	W. E. Freeman
Lafayette College, Easton, Pa	2	L. J. Conover
Lehigh Univ., Bethlehem, Pa	2	J. L. Beaver
Lewis Inst., Chicago, Ill	5	F. A. Rogers
Louisiana State Univ., Baton Rouge, La	4	M. B. Voorhies
Louisville, Univ. of, Louisville, Ky	4	J. M. Roberts
Maine, Univ. of, Orono, Maine	1	Wm. E. Barrows, Jr.
Marquette Univ., Milwaukee, Wis	5	F. A. Kartak
Mass. Inst. of Tech., Cambridge, Mass	1	W. H. Timbie
Mich. Col. of Mining & Tech., Houghton, Mich	5	G. W. Swenson
Michigan State Col., East Lansing, Mich	5	W. A. Murray
Michigan, Univ. of, Ann Arbor, Mich	5	S. S. Attwood
Milwaukee Sch. of Engg., Milwaukee, Wis	5	O. Werwath
Minnesota, Univ. of, Minneapolis, Minn	5	J. H. Kuhlmann
Mississippi State Col., State College, Miss	4	L. H. Fox
Missouri Sch. of Mines & Met., Rolla, Mo	7	I. H. Lovett
Missouri, Univ. of, Columbia, Mo	7	M. P. Weinbach
Montana State Col., Bozeman, Mont	9	J. A. Thaler
Nebraska, Univ. of, Lincoln, Neb	6	F. W. Norris
Nevada, Univ. of, Reno, Nevada	8	S. G. Palmer
Newark Col. of Engg., Newark, N. J	3	J. C. Peet
New Hampshire, Univ. of, Durham, N. H	1	L. W. Hitchcock
New Mexico, Univ. of, Albuquerque, N. M	7	Chester Russell
New York, Col. of the City of, New York, N. Y	3	Harry Baum
New York Univ., Univ. Heights, N. Y	3	H. N. Walker
North Carolina State Col., Raleigh, N. C	4	R. S. Fouraker
North Carolina, Univ. of, Chapel Hill, N. C	4	W. J. Miller
North Dakota State College, Fargo, N. D	6	H. S. Rush
North Dakota, Univ. of, Grand Forks, N. D	6	H. F. Rice
Northeastern Univ., Boston, 17, Mass	1	Wm. Lincoln Smith
Notre Dame, Univ. of, Notre Dame, Ind	5	J. A. Caparo
Ohio Northern Univ., Ada, Ohio	2	I. S. Campbell
Ohio State Univ., Columbus, Ohio	2	F. C. Caldwell
Ohio Univ., Athens, Ohio	2	A. A. Atkinson
Oklahoma Agri. & Mech. Col., Stillwater, Okla	7	Albrecht Naeter
Oklahoma, Univ. of, Norman, Okla	7	C. T. Almquist
Oregon State Col., Corvallis, Ore	9	F. O. McMillan
Pennsylvania State Col., State College, Pa	2	L. A. Doggett
Pennsylvania, Univ. of, Philadelphia, Pa	2	C. D. Fawcett
Pittsburgh, Univ. of, Pittsburgh, Pa	2	H. E. Dyche
Porto Rico, Univ. of, Mayaguez, P. R	3	Miguel Wiewall, Jr.
Pratt Inst., Brooklyn, N. Y	3	C. C. Carr
Princeton Univ., Princeton, N. J	2	Malcolm MacLaren
Purdue Univ., Lafayette, Ind	5	A. N. Topping
Rensselaer Poly. Inst., Troy, N. Y	1	F. M. Sebast
Rhode Island State Col., Kingston, R. I	1	William Anderson
Rice Inst., Houston, Texas	7	J. S. Waters
Rose Poly. Inst., Terre Haute, Ind	5	C. C. Knipmeyer
Rutgers Univ., New Brunswick, N. J	3	F. H. Pumphrey
Santa Clara, Univ. of, Santa Clara, Calif	8	G. L. Sullivan
South Carolina, Univ. of, Columbia, S. C	4	T. F. Ball
South Dakota State Col., Brookings, S. D	6	Wm. H. Gamble
So. Dak. State Sch. of Mines, Rapid City, S. D	6	J. O. Kammerman
South Dakota, Univ. of, Vermillion, S. D	6	C. W. Caldwell
So. California, Univ. of, Los Angeles, Calif	8	N. C. Clark
Southern Methodist Univ., Dallas, Texas	7	E. H. Flath
Stanford Univ., Stanford, Calif	8	H. H. Skilling
Stevens Inst. of Tech., Hoboken, N. J	3	H. C. Roters
Swarthmore Col., Swarthmore, Pa	2	H. M. Jenkins
Syracuse Univ., Syracuse, N. Y	1	C. W. Henderson
Tennessee, Univ. of, Knoxville, Tenn	4	J. G. Tarboux
Texas Agri. & Mech. Col., Col. Station, Texas	7	N. F. Rode
Texas Tech. Col., Lubbock, Texas	7	W. F. Helwig
Texas, Univ. of, Austin, Texas	7	J. A. Correll
Utah, Univ. of, Salt Lake City, Utah	9	J. H. Hamilton
Vermont, Univ. of, Burlington, Vt	1	L. P. Dickinson
Virginia Military Inst., Lexington, Va	4	S. W. Anderson
Virginia Poly. Inst., Blacksburg, Va	4	Claudius Lee
Virginia, Univ. of, University, Va	4	J. S. Miller
Washington, State Col. of, Pullman, Wash	9	O. E. Osburn
Washington Univ., St. Louis, Mo	7	H. G. Hake
Washington, Univ. of, Seattle, Wash	9	J. R. Shuck
West Virginia Univ., Morgantown, W. Va	2	A. H. Forman
Wisconsin, Univ. of, Madison, Wis	5	C. M. Jansky
Worcester Poly. Inst., Worcester, Mass	1	Carl D. Knight
Wyoming, Univ. of, Laramie, Wyo	6	G. H. Sechrist
Yale Univ., New Haven, Conn	1	W. B. Hall
Total 112		

At the time of going to press for this issue, the list of student officers was not sufficiently complete to include.

Affiliated Student Society

Brown Engineering Society.................... Brown Univ., Providence, R. I.

Industrial Notes

General Cable Elects New Officers.—At a recent meeting of the Board of Directors of the General Cable Corp., New York, Dwight R. G. Palmer was elected president succeeding H. T. Dyett, whose resignation was accepted with great regret. At the same meeting, Dr. Frank M. Potter was elected vice-president.

A New Condenser Oil.—The Baker Castor Oil Co., 120 Broadway, New York, announces a recent development in "DB" oil for oil type and impregnated paper type electrical condensers. Generous samples are offered gratis for tests.

Automatic Voltage Booster.—Ferranti Electric Limited, Toronto, has just announced an automatic voltage booster for use on rural lines. There are numerous applications for this type of equipment in outlying sections where distribution transformers are distant from the nearest sub-station. The automatic voltage booster gives an immediate boost of five or ten per cent. This equipment is said not only to render better service to the consumer by maintaining voltage, but also increases revenue, resulting in improved operation for both the customer and the utility company.

Metal Clad Switch.—The Delta-Star Electric Co., Chicago, Ill., has developed a new metal clad switch for service up to 15 kv. This switch serves as a safe, convenient and easily installed three pole group operated switch for use in industrial plants. The three switch blades carrying fuses are interlocked and simultaneously opened and closed by means of a locking type external handle. A screened opening permits easy inspection of the fuses and sufficient ventilation for the equipment. Above the screened opening is a panel easily removed for replacement of blown fuses.

Meter Connection Box.—The Corcoran-Brown Lamp Company, Cincinnati, pioneers in the meter enclosure business, announces a new meter connection box, the C-B 14. Made of rust resisting, silicon aluminum alloy, it is said to be the smallest meter enclosure for outdoor metering on the market, yet ample in size to accommodate any type of bottom connected meter in general use, disconnect and test device with adequate wiring space. The feature of greatest interest is the disconnect test block, which is arranged on the meter side for the same sequence as meter terminals, and provides sixty ampere capacity for 3-wire, 230-volt service (100-ampere disconnect may be provided). All solder lugs for connection of leads to and from the disconnect test block are eliminated. For test purposes a screw driver is the only tool that is required; no test links, nuts, etc., need be removed.

Automatic Motor Oilers.—The Speedway Mfg. Co., Cicero, Ill., makers of Speedway portable electric tools, announces a line of automatic oilers to be known as Speedway Oilers. These new oilers are of two types: "constant level" and "thermal." The constant level oilers are designed especially for use on electric motor bearings and other reservoir bearings with oil-ring, packing, or ball or roller bearings where oil in the reservoir should be maintained at a determined level. This is done by means of a tube which permits air to enter and oil to flow from the reservoir when the level of oil in bearing reservoir drops below the fixed and proper level—automatically stopping the flow of oil when this level is attained. The thermal oilers, designed for use on sleeve bearings of the open type, are operated wholly by change in the bearing temperature. Heat in the bearing causes an expansion of the air in the thermal chamber, forcing just enough oil to the bearing.

Pole Stubbing Clamps.—The Malleable Iron Fittings Co., Branford, Conn., has developed new and improved pole stubbing clamps, for application where low cost line maintenance is essential, and is distributing data on these clamps including the wedged band type and four others, with "before and after" pictures of the tests to destruction of poles or stubs. Instead of replacing a pole rendered unsafe by ground-line decay, it is simply banded to a stub extending 6 or 7 feet above ground, after which the pole is cut and supported entirely by the stub. In the tests the relatively cheap 8-band, heavy duty, wedge type stubbing clamp showed no distortion in breaking a new full-treated pine stub measuring approximately 12 inches in diameter at ground-line. Bands of proper lengths are bent to U-shape readily around the pole and the stub, and are inserted in spaced slots in the two principal castings for each band unit—two pairs of two overlapping bands for each band unit. A through-bolt is inserted through one wedging casting, fitting into the principal stubbing casting, and then through the principal casting and the wedging casting in reverse order on other side. Tightening the through-bolt draws the clamp tight and the principal castings seat between pole and stub—forming reverse bends in bands which, together with the deforming action of the wedging castings on the bands, firmly locks the bands against the slightest slippage. Two such units, spaced about 4 feet apart, comprise a complete pole stubbing clamp set.

Trade Literature

Cable.—Bulletin L-20583, 4 pp. Describes "Armortite" underground cable for street and airport lighting. Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

Portable Testing Equipment.—Bulletin GEA-1754, 4 pp. Describes G-E portable testing sets for supplying voltage or current capacity for testing, research, etc. General Electric Co., Schenectady, N. Y.

Condensers.—Catalog, 44 pp. Describes a comprehensive line, with prices, of wet and dry electrolytic, paper and mica condensers. Solar Mfg. Corp., 599 Broadway, New York.

Electrical Exhibits at Chicago Fair.—Pamphlet, 32., printed in four colors, describes the electrical exhibits at the Chicago Century of Progress Exposition. The Delta-Star Electric Co., Chicago, Ill.

Humidity Instruments.—Bulletin 108. Describes direct-reading precision hygrometers, recorders, and other simple instruments used for determining accurately true air conditions. Amthor Testing Instrument Co., 309 Johnson St., Brooklyn, N. Y.

Generators.—Bulletin 1158, 4 pp. Describes a line of bracket bearing alternating-current generators, built in ratings from 30 to 1000 kva. These generators are suitable for coupled or belted service to high speed steam or internal combustion engines, and for gearing to steam turbines. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Small Motors.—Bulletin GEA-1769, 4 pp. Describes fractional horsepower, single-, phase, repulsion-start, induction motors type RSA, form C. Capacities 1–6 to 1–3 hp., 110–220 volts, 60 cycles, with high starting torque and good reserve capacity. General Electric Co., Schenectady, N. Y.

Oil Circuit Breakers.—Bulletin L-20565, 8 pp. Describes type FO-22 oil circuit breakers. These new, self-contained, reclosing breakers are particularly adapted for use on rural and other circuits where a low-cost reclosing breaker is desired. All operating details are entirely enclosed and simple in construction to minimize servicing at the distant locations where this breaker will be used. Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Lightning Arresters.—Bulletin GEA-1792, 6 pp. Describes the new G-E pellet lightning arresters for pole mounting. These units retain the operating principles and characteristics of the previous designs but are improved mechanically. Outstanding are the use of a single series gap in a sealed chamber, assuring permanent exclusion of atmospheric influences; a clamp-type ground terminal, which saves time and expense when installing; and a dual hanger for mounting the arrester individually or in combination with a fuse cutout. General Electric Co., Schenectady, N. Y.

Rheostats.—Bulletin 8001. Describes new sliding contact tubular rheostats (laboratory type) designed for the accurate control of currents up to 25 amperes. They are arranged for potentiometer connection and may be obtained with non-inductive or tapered resistance windings. Three sizes—8 inch, 16 inch, and 20 inch lengths cover a very wide range of resistance values. A feature of the latest design is a single point, silver contact. Rheostats equipped with micrometer drive are provided with a clutch which readily permits single hand adjustment of the slider. Ward Leonard Electric Co., Mount Vernon, N. Y.